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THE R-401M RADIO RELAY STATION
TECHNICAL DESCRIPTION AND OPERATING INSTRUCTIONS

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TECHNICAL DESCRIPTION AND OPERATING INSTRUCTIONS

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CHAPTER I

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PURPOSE AND BASIC TACTICO-TECHNICAL CHARACTERISTICS OF THE STATION

1.

Purpose of the Station

Radio relay station R-401M is designed to provide communications between control points and to furnish branch communication channels from high-capacity multi-channel radio relay stations.

In addition, the station may be used with multiplexed wire communication lines. This equipment provides communication both when in motion and from a fixed position.

2.

Composition of the Station

Station R-401M is manufactured in two models: a truck model and a stationary model. The equipment of the truck version is mounted in a special KUNG-2 type van which is installed on the chassis of a GAZ-63 truck (Fig. 1). The van is provided with a bench area for the equipment, storage battery compartments, spare part and accessory containers, a locker for the personal belongings of the crew, a heating unit, input recesses, etc.

Each station consists of two identical half-sets of equipment. An equipment half-set contains the following basic components: frequency filter section, transceiver section, telephone channel section, telegraph channel section, mains board, charging board, PES-0.75 or AB-1-P/30 battery charger, six 5NKN-45 storage batteries, stationary antenna, mast with accessories and two coaxial cable feeders. Also included in the station are: a whip antenna for operation while in motion, a power amplification section, a device for adjusting the telegraph channels and checking out the relays, a mains board, a G-74 power take-off generator, a TAI-43 telephone set as well as spares and accessories.

The stationary model (R-401SM) which is shipped in packing cases, includes the same equipment except for the whip antenna, either the PES-0.75 or AB-1-P/30 battery charger and certain other accessories which are incidental only to truck van operation.

The sections of each half-set are installed in a metal rack (Fig. 2). In the truck model the racks are fastened to the operating bench and forward wall of the van by means of shock absorbers. The arrangement of the equipment in the van is illustrated in Fig. 3. The fixed station equipment arrangement is similar to that of the mobile model.

The design of the apparatus and equipment of the station is such as to provide for rapid dismantling and removal of the necessary units for operation outside the van or working area, and also for rapid re-installation. The removable equipment set includes: the frequency filter section, the transceiver section,

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FIG. 1 - Station in Mobile Condition

1. Mast Erectors
2. Input Recess (Port)
3. Transmission Line Lead-Ins
4. Ventilation Cover for Storage
Battery Compartments

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the telephone channel section, the telegraph channel section, the 5NKN-45 storage batteries (two of them), the antenna pack, the mast, the guy and support line pack, the pack containing the mains board and microtelephone operator's set and the bay with connecting cables.

When removed, the various sections and mains board are accommodated in carrying kits.

3.

Basic Equipment Data: Range of Communication

Over wooded and steppe terrain of average relief, when working with stationary antennas and without the power amplification unit, the stations are capable of providing a communication range of not less than 45 kilometers in one interval and up to 120 kilometers if two intermediate stations are employed.

Even greater range is possible in a single interval over open routes with direct line-of-sight between the antennas of two stations.

It should be borne in mind that, when intermediate stations are used, the addition of each interval results in an increased noise level in the channels of the radio link. Normal operational conditions over the radio link in this case require higher levels of the RF signal within each interval and, consequently, a reduction in the range of each interval in comparison with that which is provided when no relay is employed. This is, in fact, the explanation for the somewhat shorter range of communication over the radio link when two intermediate stations are used than that which would result from the tripled range of a single interval.

With the radio link multiplexed by type P-310 or P-312 wire multiplexing equipment, the effective range of the station over one interval lies somewhere between 10-12 km.

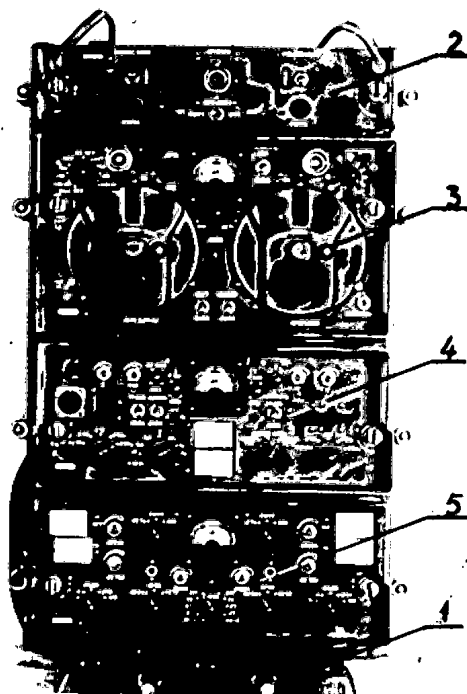
The use of the power amplification section, under conditions of wooded and steppe terrain of average relief, makes it possible to increase the range of communication over a single interval to 60-70 km. When operating the mobile station with a whip antenna and the fixed station with a Yagi-type antenna raised to its full height, communication between them over the first telephone channel may be established at distances of up to 25 km. In this instance single-channel working and the connection of the power amplification section is permitted.

Band

The station operates in the meter waveband at frequencies of 60-69.975 (5.0-4.29m). The entire band is divided into 134 fixed frequencies with an interval of 75 kc (from No. 21 to No. 154). To fixed frequency No. 21 corresponds 60.00 Mc; to fixed frequency No. 154 corresponds 69.975 Mc. The band of fixed frequencies of the R-401M from fixed frequency No. 101 to fixed frequency No. 154 is common with that of station R-401, with fixed frequency No. 1 of the R-401 corresponding to fixed frequency No. 101 of the R-401M, fixed frequency No. 2 of the R-401 corresponding to fixed frequency No. 102 of the R-401M, etc.

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370**FIG. 2 - Mounting Rack of One Half-Set**

1. Rack Frame
2. Frequency Filter Section
3. Transceiver Section
4. Telephone Channel Section
5. Telegraph Channel Section

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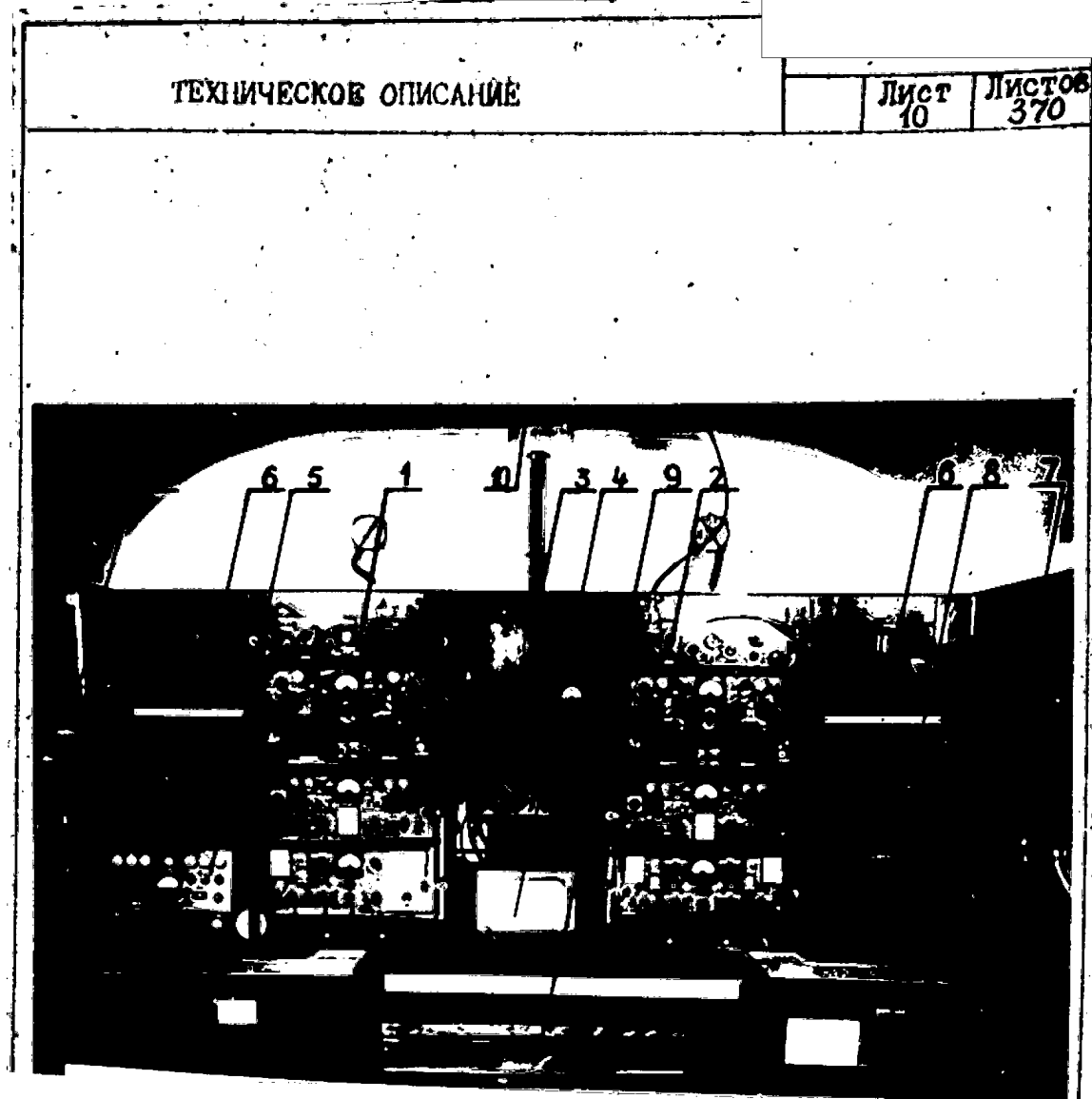


FIG. 3 - Arrangement of Equipment in Van

1. Mounting Rack of Half-Set A
2. Mounting Rack of Half-Set B
3. Power Amplification Section
4. Telegraph Channel Adjusting Device and Relays
5. Mains Board
6. Line Boards
7. Charging Boards
8. Telephone Set Type TAI-43
9. Battery Charger
10. Clock

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The vernier-dial devices of the station permit continuous adjustment of the working communication frequencies within this band.

Operating Modes

The station provides for simultaneous duplex working over two telephone and two telegraph channels on two communication frequencies. Each telephone channel may be connected in a two- or four-wire circuit; that is, with or without separation of reception and transmission by channel. The first telephone channel permits secondary multiplexing by telegraph channels with the use of P-313 wire multiplexing equipment.

The second telephone channel also permits secondary multiplexing by telegraph channels; however, in view of the fact that the second channel is supersonic, when it is secondarily multiplexed by P-313 equipment telegraph operation over it may be somewhat less satisfactory than over the first channel. For this reason, it is recommended that the first telephone channel be worked with the P-313 multiplexing equipment.

The telephone channels permit the transmission of fixed images by means of P-106 phototelegraph equipment.

The telegraph channels provide for unipolar operation of ST-35 printing equipment and bipolar operation of P-100 equipment.

Telegraph operation is possible without separation of the reception and transmission circuits of the channel at the telegraph set ("single-wire simplex") or with such separation ("two-wire simplex"), and also over the midpoints of the two-wire connecting lines of the first and second telephone channels by means of differential transformers located at the station.

The equipment of the station makes possible, with reduced range, external multiplexing of the radio channel by means of P-310, P-311 and P-312 wire communication equipment, with communication retained over the first telephone channel of the station.

When working with one's own multiplexing equipment, any channel can be separated at any intermediate station of the radio link. The remaining channels are relayed on low (audio or supersonic) frequency. When P-310, P-311 and P-312 wire equipment is used for multiplexing, only the first telephone channel can be separated.

The outputs of the telephone channels of the station are capable of being joined to the telephone channels of wire and radio relay communication equipment.

Two systems of calling are employed by the telephone channels of the station. The service call system provides only for calling any station of the radio link. The operational call system provides for magneto ringing over the radio link between switchboards or subscribers. The station can operate over the first telephone channel in a simplex (single-channel) mode.

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The coefficient of non-linear distortion of the telephone channels with a four-wire connection (mode "4TG") and input level of -0.4 nepers (520 mv) over one interval of the radio link does not exceed 4%.

The input and output impedance of the telephone channels of the station equal 600 ohms.

The rated levels of the telephone channels, measured at a frequency of 800 cycles, have the following values:

- with a two-wire connection, the input level equals -1 neper (285 mv), the output level equals -2.0 nepers (105 mv);

- with a four-wire connection with relay of magneto ringing: a) mode "4TF1" - input and output levels equals -1.4 nepers (190 mv), b) mode "4TF2" - input level equals -1.4 nepers (190 mv), output equals +0.4 nepers (1.16v). The "4TF2" mode is used when working with special purpose equipment;

- with a four-wire connection without relay of magneto ringing (mode "4TG"), the input and output levels equal -0.4 nepers (520 mv).

At nominal power source voltage, the output level in the telephone channels can be adjusted by means of the test instruments incorporated in the station with an accuracy of ± 0.2 nepers.

Telegraph channel quality is evaluated, basically, by two criteria: maximum speed of telegraphy and coefficient of telegraphic distortion. The telegraph channels of the R-401M permit operation at a telegraphy rate of up to 70 bauds. The error in the neutral setting of the telegraph channels when using the adjusting device for these channels does not exceed 5% at a telegraphy speed of 50 bauds.

Channel characteristic non-uniformity for external multiplexing over one interval of the radio link in a frequency band from 0.3 to 16 kc does not exceed +0.2 nepers (946 mv) and -0.5 nepers (470 mv) in relation to the level at a frequency of 9 kc. The rated levels of the external multiplexing channel are the following: input +0.4 nepers (1.16v); output not less than -2.0 nepers (105 mv). The input and output impedances of the external multiplexing channel equal 600 ohms.

Transmitter Power

The power fed by the transmitter to the antenna transmission line (feeder) is not less than 2.5 watts at rated power supply voltage and average output tube parameters. If the voltage of the power supply sources decreases (to 11 volts in the case of the battery voltage and by 10% from the rated in the case of the a-c mains voltage), the power fed by the transmitter to the antenna transmission line (feeder) is not less than 1.5 watts.

When working with the power amplification section, the power fed to the antenna transmission line (feeder) is not less than 25 watts.

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Receiver Sensitivity

The sensitivity of the receiving equipment (which is characterized by the minimum necessary input signal level, with a signal frequency deviation of 7 kc, normal output level and a signal/noise ratio of 20 at the telephone channel output) is not worse than 2 microvolts. The sensitivity of the receiving equipment remains practically unchanged despite fluctuations in feed voltages of $\pm 10\%$.

Receiver Selectivity

Sensitivity attenuation over the image channel is not less than 9 nepers (7950 times) for the first intermediate frequency and 11 nepers (60,000 times) for the second intermediate frequency. Sensitivity attenuation over other spurious channels, with detuning of from 75 to 300 kc, is not less than 8.85 nepers (7000 times), and with detuning above 300 kc, not less than 11.5 nepers (100,000 times), with the exception of frequencies

$$f_H - \frac{f_{\text{inter}}}{2} \quad \text{and} \quad 2f_H - f_{\text{inter}_1},$$

for which attenuation is not less than 7.5 nepers (1860 times).

The frequency passband of the receiving equipment at a level of 0.5 is not less than 46 kc.

Transmitter and Receiver Frequency Stability

Transmitter and receiver frequency stability make it possible to initiate communication without the need of searching out the proper frequency and to conduct communication without manual tuning. Transmitter and receiver frequency adjustment is accomplished, through the use of the dials, with an accuracy of not worse than ± 7 kc. After replacement of the tubes of the exciter and frequency modulator in the transmitter, and those of the first heterodyne and frequency control unit in the receiver, the calibration of transmitter and receiver frequency must be corrected by the crystal calibration unit of the station.

Such correction of the calibration of transmitter and receiver frequency must also be made at the time of technical inspections of the station.

When the transmitter or receiver is switched on, as the tubes and circuit elements of the exciter in the transmitter and first heterodyne in the receiver become warm, their frequency will change.

Fifteen minutes after they have been switched on, the frequency of the transmitter and receiver is for all practical purposes established and almost no further frequency change occurs.

The sum frequency deviation, due to fluctuations of $\pm 10\%$ from the rated feed voltages and after fifteen minutes heating time, does not exceed ± 7.5 kc for the transmitter exciter and ± 7 kc for the receiver heterodyne.

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...horizontal antenna - about 750 (Fig. 56). The gain of the antennas, in comparison with a half-wave dipole, is not less than 6 decibels (four times in power). Crosstalk attenuation between antennas is not less than 38 decibels (80 times).

The receiver and transmitter are connected to the antennas by means of type RK-1 feeders 25 meters in length.

During mobile operation, high-frequency signals are received and transmitted by means of a half-wave whip antenna installed on the roof of the van.

A frequency filter section is employed in order to provide simultaneous operation of transmitter and receiver over a single antenna.

The electrical characteristics of the frequency filter section are the following: the reduction of the signal passing from the transmitter to the antenna (or of the signal passing from the antenna to the receiver) does not exceed 3 decibels, while attenuation of the transmitter signal at the receiver input must not be less than 50 decibels.

Station Power Supply

The station may derive its electric power either from storage batteries or from the a-c 127/220 volt mains. Each equipment half-set contains three storage battery groups consisting of two type 5NKN-45 batteries. One group of batteries provides eight hours of continuous operation for one half-set under operating conditions (without the power amplification section).

Power requirements of one equipment half-set from the storage batteries are the following:

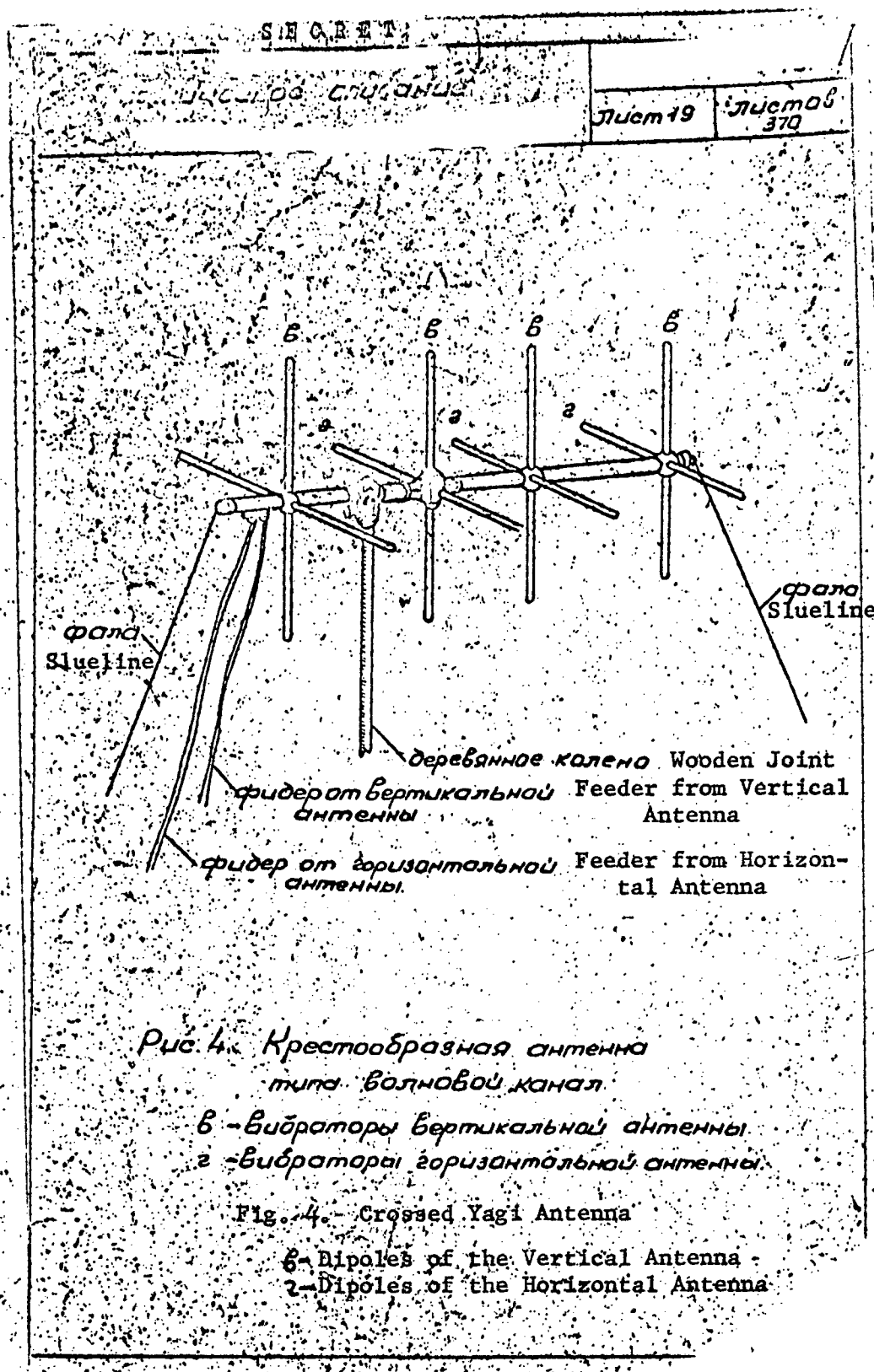
- in the operating condition with power amplification section off - not more than 75 watts;
- in the standby condition - not more than 35 watts;
- in the operating condition with power amplification section on - not more than 180 watts.

The power requirements of one equipment half-set from the a-c mains are the following:

- in the operating condition - not more than 190 watts;
- in the standby condition - not more than 65 watts;
- in the operating condition with power amplification section on - not more than 270 watts.

The power consumed by the entire station from the a-c mains with both half-sets operating under maximum load (transmission of ringing, dial illumination, van illumination, power amplification section connected) is not more than 600 watts.

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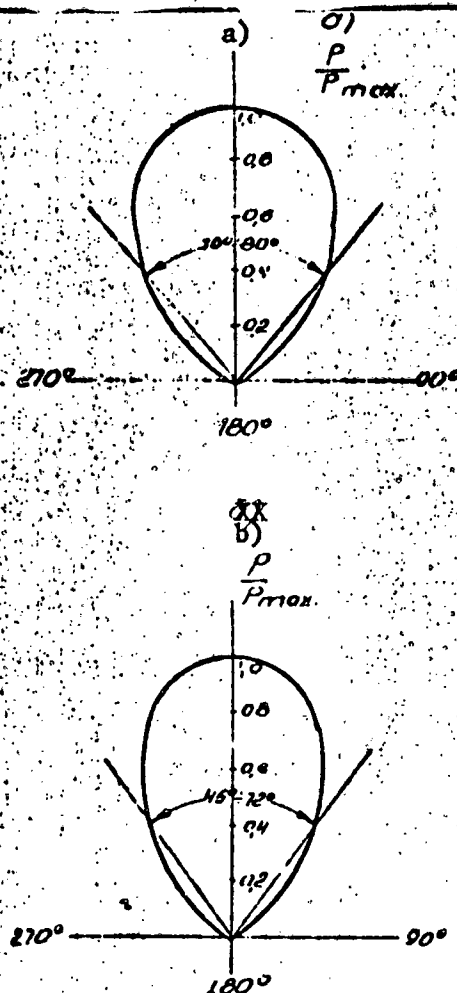


Fig. 5 Antenna Directional Characteristics

Рис 5. Характеристики направленности антенн.

- a) In the Horizontal Plane of the Vertical Antenna
 а) в горизонтальной плоскости вертикальной антенны;
 б) в горизонтальной плоскости горизонтальной антенны.
 b) In the Horizontal Plane of the Horizontal Antenna
 На рисунке приведены главные лепестки диаграмм направленности.

The drawing shows the major lobes of the directional (radiation) patterns.

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The station is so designed as to permit normal operation despite feed voltage fluctuations of $\pm 10\%$ from their rated values.

In order to permit adjustment of the voltage when the station is powered from the a-c mains, an autotransformer is installed in the mains board of the station.

The storage batteries are charged by means of type PES-0.75 or AB-1-P/30 battery chargers or from a type G-74 generator operating from a power take-off box connected to the truck engine.

Special converters (feed elements), located in the transceiver and telegraph sections are used to feed the anode and screen circuits of the tubes of the transceiver and telegraph sections and also the line circuits of the P-100 equipment.

Time Required to Assemble and Dismantle Station

The time required, by a 5-man crew, to set up or dismantle one intermediate station (installation or disassembly or two antenna-mast units) does not exceed 45 minutes.

The antenna-mast unit is so designed as to permit assembly and disassembly of the station in spatially limited areas (12 X 14m for one antenna).

Station Crew

The personnel assigned to a station consists of 5 men:

- 1 - station chief
- 1 - senior radio relay mechanic
- 2 - radio relay mechanics
- 1 - electromechanic (also drives truck)

Miscellaneous Station Characteristics

The R-401M station is mounted in a standardized KUNG-2 van, metal-lined, which is installed on the chassis of a GAZ-63 truck.

The dimensions of the vehicle and van used to transport the station are the following:

Length	-	5500 mm
Width	-	2260 mm
Height	-	3180 mm

With the vehicle fully loaded with fuel, lubricants and water, the weight of the station does not exceed 5200 kg.

Full gasoline capacity of the vehicle is as follows:

Tank Under Seat	-	90 liters
Tank Under Van	-	105 liters

The average consumption of fuel by the mobile station is 30 liters per 100 km over average-quality roads.

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The total number of radio tubes used in a single half-set is 28; including:

- in the transmitter - 6 (5 12Zh1L and 1 12P17L);
- in the receiver - 14 (12Zh1L);
- in the telephone section - 4 (12Zh1L);
- in the telegraph section - 4 (12Zh1L).

The power amplification section uses one GU-50 tube.

4.

Operational Modes of the Station

The apparatus and equipment composition of the station make possible operation in the following modes:

- terminal mode (with simultaneous operation in two independent directions);
- relay mode;
- junction mode (with the possibility of branching off any channel or any combination of channels).

Each equipment half-set can be put on a standby reception mode and, in addition, the station is capable of single-channel (simplex) operation.

Terminal Mode Station Operation

Fig. 6 shows a block diagram of a station half-set operating in the terminal mode.

The telephone sets of the subscribers are connected by wire connecting lines to the differential systems (hybrids) ΔC of the first and second telephone channels. Having passed through differential system (hybrid), ΔC amplitude limiter AO and low-frequency filter ΦH with a passband up to 2.7 kc, the signal from the subscribers of the first channel reaches the modulation amplifier of the radio transmitter. The signal from the second channel subscriber, having passed through the differential system (hybrid) and amplitude limiter AO, reaches modulator M, where the audio spectrum is converted to a higher frequency region by means of subcarrier oscillator Γ_1 . As a result of the amplitude modulation of the oscillator frequency ($f_H = 7.4$ kc), by the audio frequency spectrum, two sidebands are formed.

By means of band filter $\Pi\Phi$, with a 4.7-7.1 kc passband, there is discriminated only the lower frequency sideband, which reaches the input of the radio transmitter modulation amplifier. The d-c telegraph pulses from the telegraph sets, connected to the telegraph channels of the station, reach transmission relay ΠP of the proper channel. Transmission relay ΠP controls the frequency of oscillator Γ_2 in the first telegraph channel and the frequency of oscillator Γ_3 in the second.

In the case of negative (or spacing) pulses from the telegraph set, oscillator Γ_2 of the first telegraph channel generates oscillations of an 8.5-kc frequency, while in the case of positive (or marking) pulses - of 9.1 kc. Oscillator Γ_3 of the second telegraph channel generates, correspondingly, oscillations of a frequency of 12.2 and 12.8 kc.

In this way, when telegraph work is transmitted over the channels, oscillators Γ_2 and Γ_3 are frequency-keyed (modulated). The frequency-modulated oscillations pass through band filters $\Phi\Gamma_1$ -1-2 with a passband of 8.4-9.2 kc in the first channel, and $\Phi\Gamma_1$ -3-4 with a passband of 12.1-12.9 kc in the second channel, to the modulation amplifier of the radio transmitter.

The sum signal from all the channels of the station, the frequency spectrum of which is shown in Fig. 7, is amplified by the modulation amplifier and fed to the frequency modulator, by means of which the high-frequency oscillations of the radio transmitter exciter are frequency-modulated.

The frequency-modulated HF oscillations are amplified by the intermediate stage of the transmitter and reach the power amplifier stage, from the output of which they are fed over a high-frequency cable (feeder) to the transmitting antenna.

The HF oscillations, received by the antenna, travel over the high-frequency cable (feeder) to the radio receiver input, where they are amplified and converted into low-frequency signals which correspond to the modulating signals of the radio transmitter.

These signals of the radio receiver reach the filter system of the telephone and telegraph sections, where channel separation is accomplished.

The audio frequency spectrum of the first telephone channel, having passed through low-frequency $\Phi\mathcal{H}\mathcal{Y}$ with a passband of up to 2.7 kc, low-frequency amplifier Y and differential system (hybrid) $\Delta\mathcal{C}$, reaches the subscriber (Fig. 6).

The frequency spectrum of the second telephone channel, having passed through band filter $\Phi\mathcal{H}\mathcal{Y}$ with a passband of 4.7 and 7.1 kc, reaches demodulator $\Delta\mathcal{M}$, where by means of subcarrier frequency oscillator Γ_1 the audio spectrum is restored. After amplification by amplifier Y the signals of the audio spectrum reach the subscriber through the differential system (hybrid).

In order to provide for conversations over the first or second telephone channel directly from the station, both over the radio link as well as over wire lines to a switchboard, a speak-buzz unit $\mathcal{N}\mathcal{B}\mathcal{Y}$ is used, which is connected in this case to the proper channels.

The frequency-modulated oscillations of the first telephone channel pass through band filter $\Phi\mathcal{H}\mathcal{Y}$ -1-2 with a passband of 8.4 kc, amplitude limiter A0 and amplifier Y to frequency detector Δ , where they are converted into amplitude-modulated oscillations and then rectified by rectifier B. The rectified currents control the operation of receiving relay $\mathcal{N}\mathcal{P}\mathcal{P}$, the armature of which reproduces the telegraph operation by d-c signals which are fed to the line running to the telegraph set.

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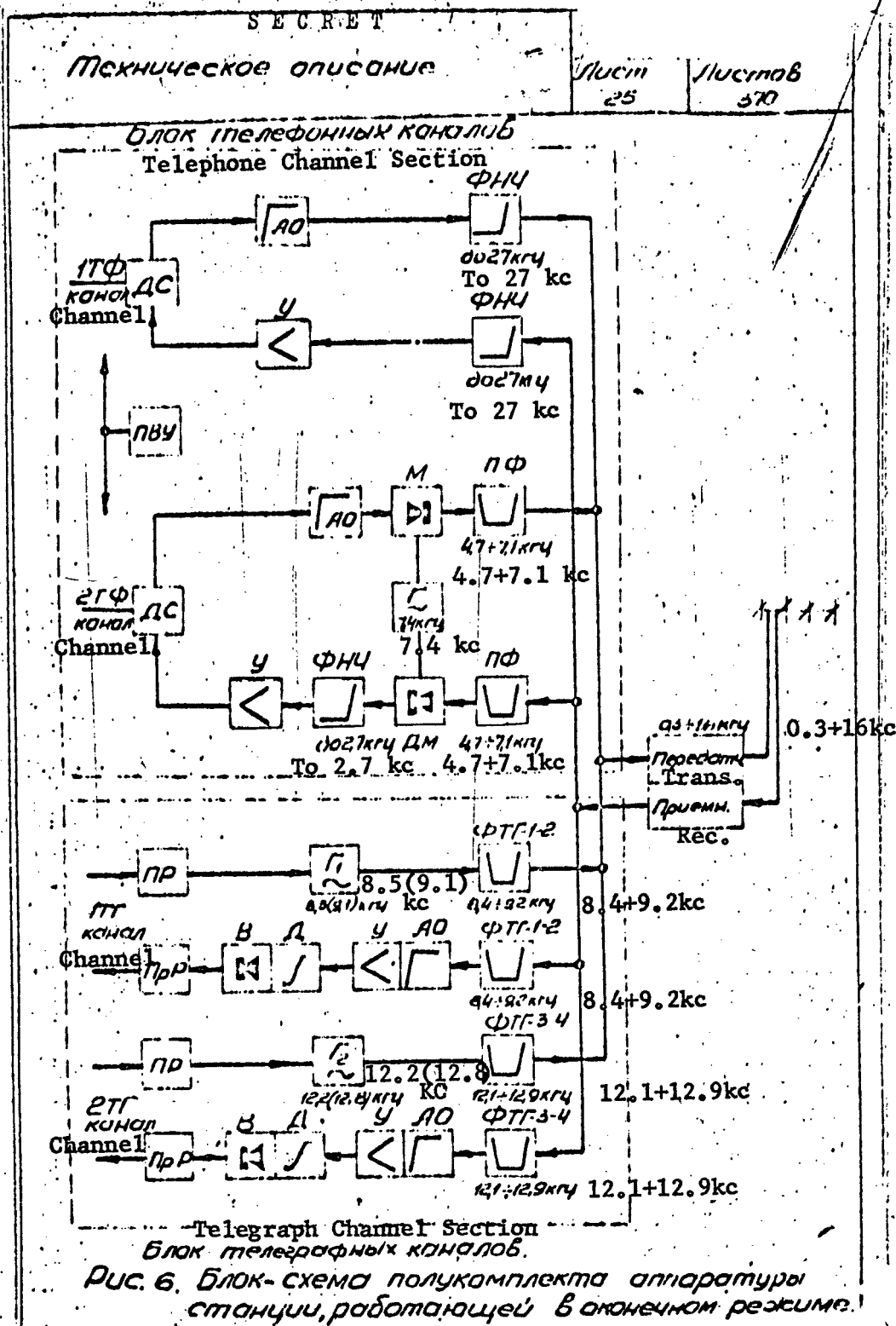


Fig. 6 Block Diagram of a Half-Set of a Station Operating in Terminal Mode

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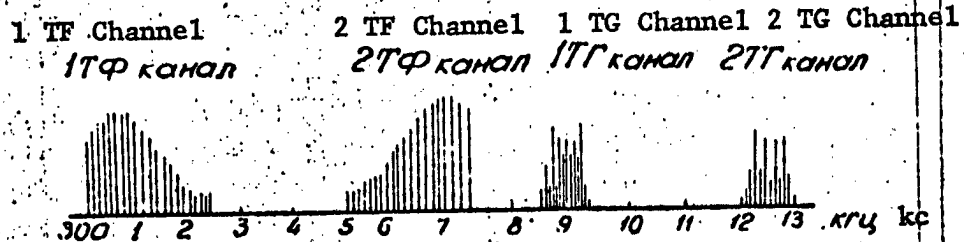


Рис. 7

Размещение спектров частот телефонных
 и телеграфных каналов.

Fig. 7 Arrangement of the Frequency Spectra of the
 Telephone and Telegraph Channels

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The frequency-keyed oscillations of the second telegraph channel pass through band filter $\Phi TF-3-4$ with a passband of 12.1-12.9 kc and further over the circuits in a manner similar to that in the case of the first telegraph channel.

When the station operates in terminal mode with P-310, P-311 and P-312 multiplexing equipment, a four-wire connection circuit is employed; that is, there is separate reception and transmission.

Fig. 8 shows a block diagram of the station operating in the terminal mode. In this event, as indicated above, operation over the first telephone channel is preserved, as shown in the diagram of Fig. 6. The transmission circuit of the multiplexing equipment is connected by broad-band transformer Tp5 to the input of the modulation amplifier of the radio transmitter parallel to the transmission branch of the first telephone channel.

The reception circuit of the external multiplexing equipment is connected to the radio receiver output.

Station Operation in the Relay and Junction Modes

For station operation in the relay mode two equipment half-sets are used, one of which operates toward correspondent A, the other toward correspondent B. A block diagram of the station operating in the relay mode is shown in Fig. 9.

As is clear from the block diagram, in relay operation, all telephone and telegraph channels are set for the relay mode PETP ("RELAY"). In this case, the signals of all channels are relayed in low (audio and supersonic) frequency over a four-wire circuit. The telephone signals, received by the receiver of half-set A, pass through only the filters of this half-set and reach the modulation amplifier of the transmitter of half-set B. The telegraph signals received by the receiver of half-set A, pass through the receiving and transmitting band filters of both half-sets and reach the modulation amplifier of the transmitter of half-set B.

The relay mode in the opposite direction is effected in an analogous fashion.

In order that it be possible to call from any direction and over any telephone channel a station operating in the relay mode, the receiving branches of the telephone channels remain connected to the output of the receiving filters.

In Fig. 9 the channel switching which corresponds to the relay mode is shown in heavy bows. The dotted bows indicate channel commutation when shifted to the terminal mode.

When one or more channels are placed in terminal mode, in order to branch off the given channel or channels at a relay station, this mode of station operation is usually referred to as the "junction" or "nodal" mode.

It should be noted that when telegraph channels are relayed their electric power supply is not connected.

In the case of relay over an external multiplexing channel, the station is switched to the external multiplexing relay mode. In this event, the second telephone channel and both telegraph channels of each half-set are disconnected. The

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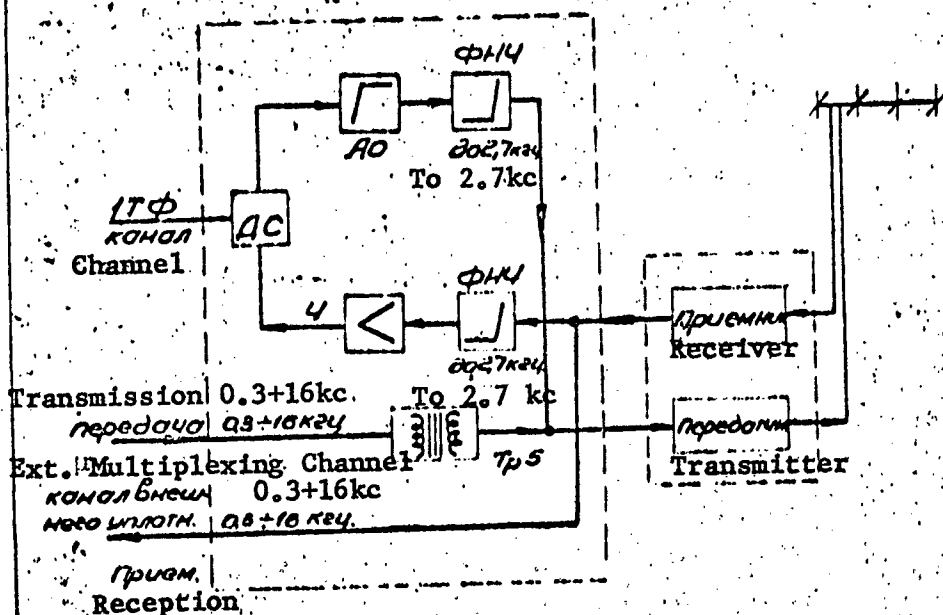


Рис. 8. Блок-схема работы станции
в качестве оконечной при
внешнем уплотнении.

Fig. 8. Block Diagram of Terminal Station Operation
with External Multiplexing

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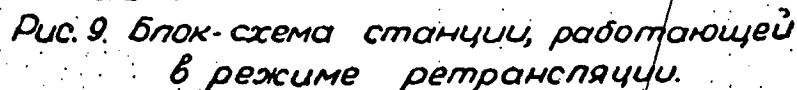


Fig. 9 Block Diagram of a Station Operating in the Relay Mode

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first telephone channel is relayed, as described above. The external multiplexing channel is relayed over a four-wire circuit. Fig. 10 shows the block diagram of a station in this type of operation.

Station Operation in the Standby Mode

At certain times during the operation of a radio link it may be necessary to disconnect the line for an unspecified period. This requirement involves the need for a means of reconnecting the line whenever necessary.

For this purpose, each half-set of terminal and intermediate stations of the radio link are placed on standby reception. In the standby reception mode there are connected only the radio receiving devices and telephone channel sections which make it possible to receive a call over any telephone channel. The receipt of a call signal over one of the channels activates the corresponding ringing receiver NT6, signal lamp $\mathcal{N}$ lights and bell 3B rings. The operator connects the transmitter and replies to the station which is calling. A block diagram of a half-set operating in the standby reception mode is shown in Fig. 11.

Station Operation in the Single-Channel Mode

With the station operating in duplex while in motion, certain specific interference occurs which has the effect of reducing the range of communication. In order to increase this range, there has been provided in the R-401M a single-channel operating mode over the first telephone channel using simplex working. Operating in this manner, with the transmitter disconnected, interference to reception is sharply reduced.

In addition, operation in the single-channel mode involves higher frequency deviation, and this results in increased noise resistance on the part of the channel. This is equivalent to increasing the range of communication while maintaining the same signal/noise ratio at the output of the channel.

The button of the operator's microtelephone is used to switch on the transmitter (it's plate voltage) in order to answer the opposite station.

In mobile operation, the antenna system consists of a half-wave rod installed on the top of the van in a special rubber insulation which simultaneously acts as a shock absorber, protecting the antenna against damage due to accidental concussion.

The power amplification section may be used, in the case of single-channel operation, in order to increase communication range when on the move.

Station Operation with Power Amplification Section

The presence of a power amplification section makes it possible to expand the tactical capabilities of the station under various conditions. Thus, for example, through the use of the power amplification section it is possible to achieve greater communication range over a single interval, to improve communication quality (that is, to reduce the noise level) over a given interval, or to provide given communication range at lower antenna height, etc.

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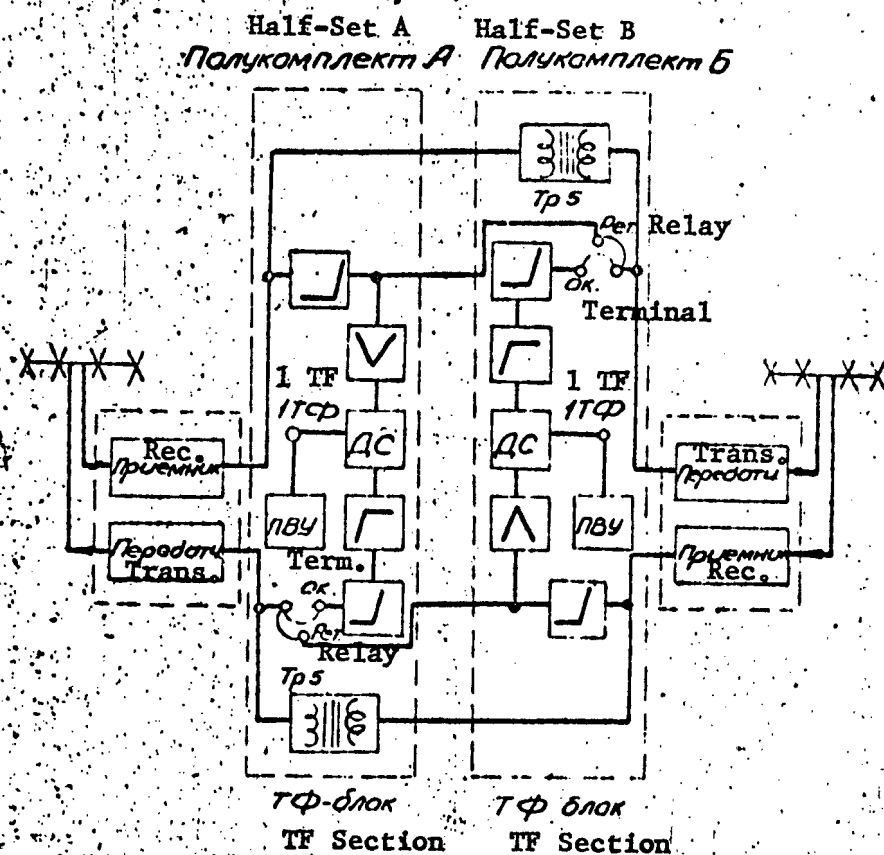
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РИС. 10.

Блок-схема работы станции
в качестве ретрансляционной
при внешнем уплотнении.

Fig. 10 Block Diagram of a Station Operating in the Relay
Mode with External Multiplexing

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The power amplification section is of particular importance in mobile operation from the point of view of increased range, both between a fixed and mobile station as well as between two mobile stations.

Figs. 12 and 13 show block diagrams of a station operating with the power amplification section. When operating with the power amplification section, the receiving antenna must be connected to the receiver through the frequency filter section.

Single-Antenna Station Operation

Operation of the receiver and transmitter over a single antenna is accomplished by means of the frequency filter section.

By means of the frequency filter section, transmitter and receiver can be worked both over a single whip antenna as well as over any (horizontal or vertical) antenna of the Yagi type.

Mobile station operation involves only the whip antenna together with the use of the frequency filter section. In the stationary model of the R-401M, when operating with a mobile station, a single whip antenna may be used or a single Yagi antenna with vertical polarization through the frequency filter section.

In the case of the joint operation of one R-401M station in motion with an R-401 station operating from a fixed position, the Yagi antenna system on the latter must be turned to an angle of 45°, as shown in Fig. 14.

A detailed description of the frequency filter section is given in Section 3, Chapter II of this Guide.

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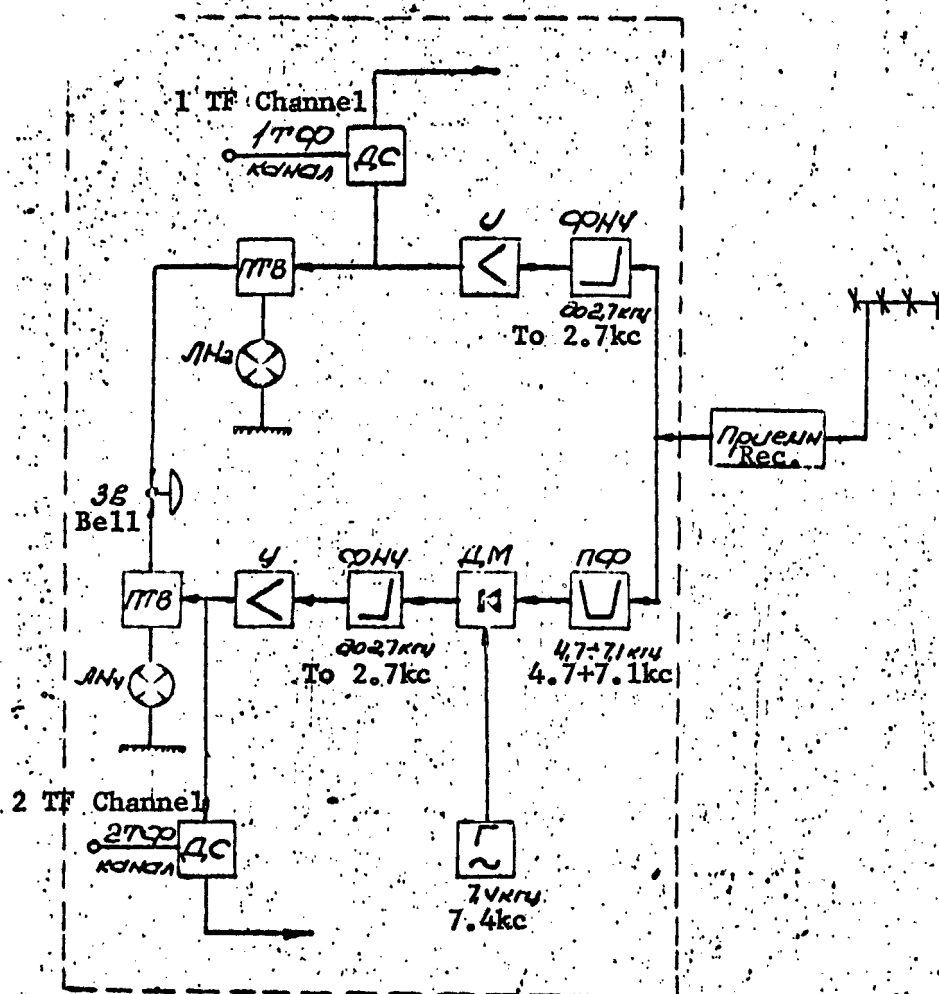
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Рис. 11. Блок-схема полуконтекста аппаратуры станции, работающей в режиме дежурного приема.

Fig. 11 Block Diagram of a Station Half-Set Operating in the Standby Mode

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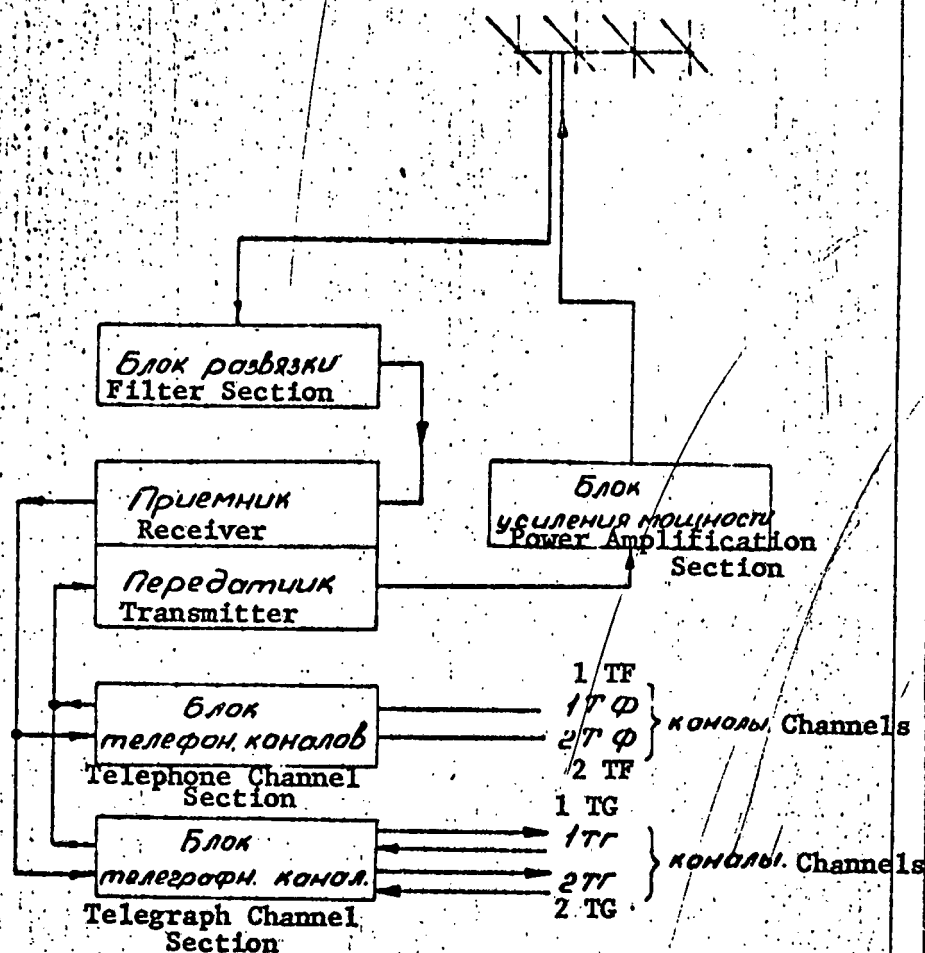
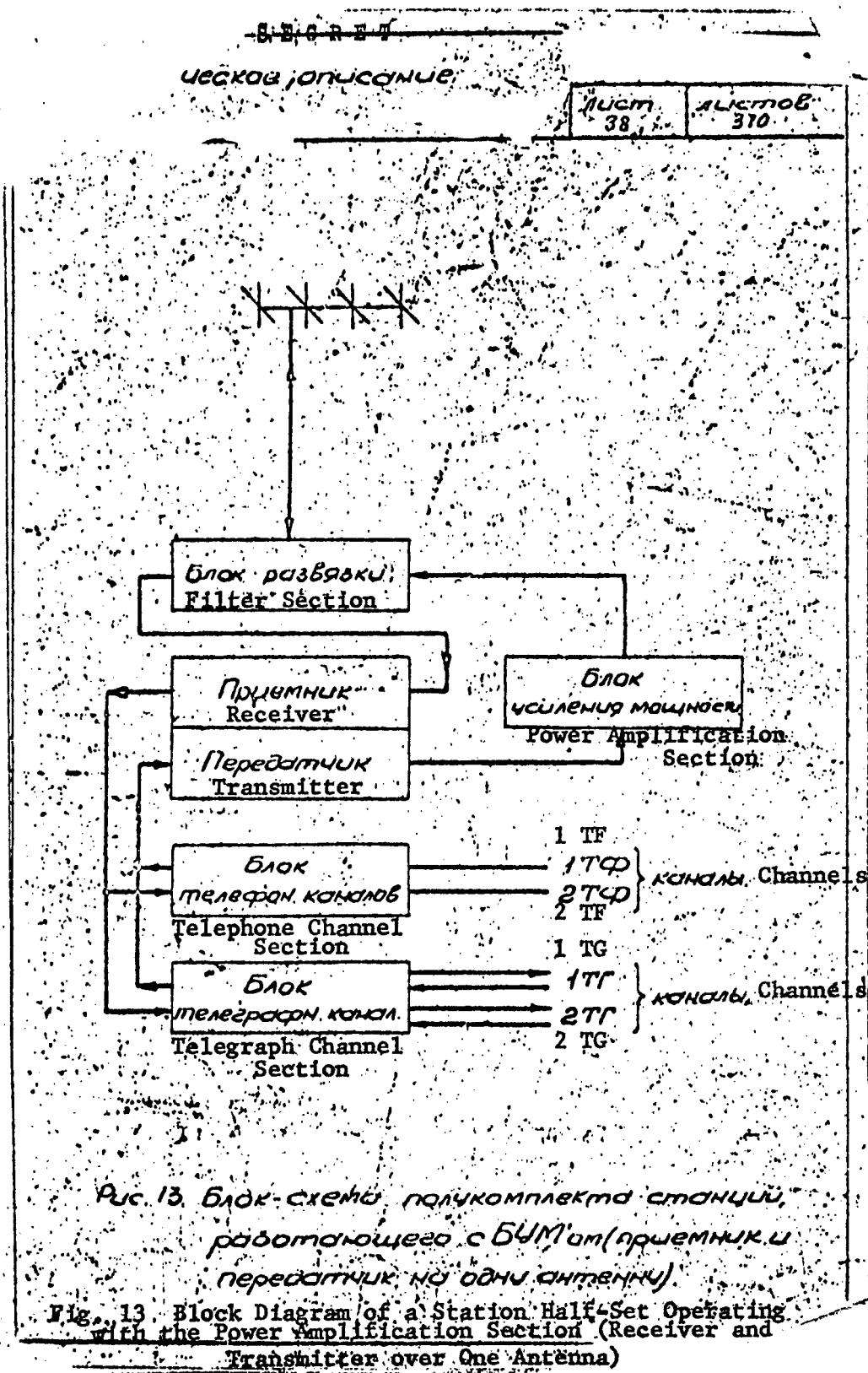
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Рис. 12 Блок-схема полуккомплекта станции,
работающего с БУМом (приемник и
передатчик на разные антенны).

Fig. 12 Block Diagram of a Station Half-Set Operating
with the Power Amplification Section (Receiver and Trans-
mitter over Different Antennas)

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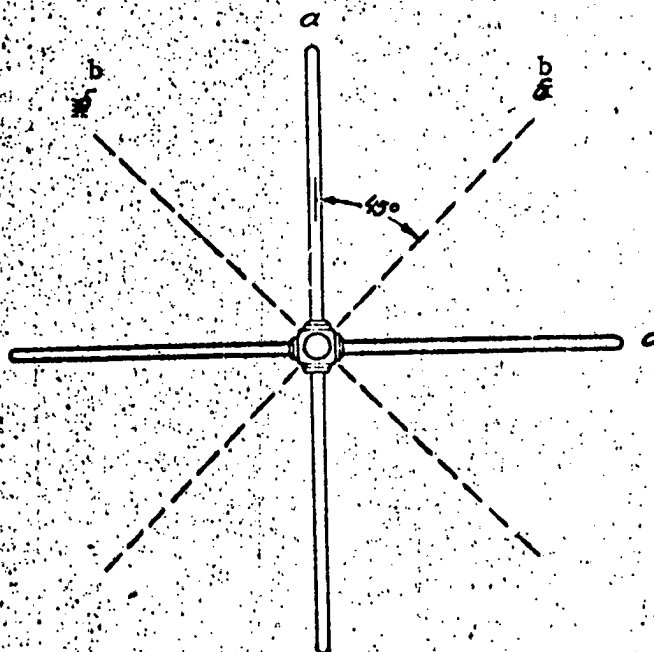
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Fig. 14 Position of the R-401 Antenna System

рис. 14. Положение антенной системы Р-401

а - нормальное положение;

б - положение для работы с подвижными станциями Р-401М и Р-403.

a - normal position

b - position for operation with R-401M and R-403 mobile stations

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CHAPTER II

DESCRIPTION OF THE STATION EQUIPMENT

1.

Arrangement of the Station in the Van

The equipment of the R-401M radio relay station is designed in the form of individual interchangeable sections:

Frequency Filter Section
Transceiver Section
Telephone Section
Telegraph Section
Power Amplification Section
Mains Board
Charging Board
Line Board

The frequency filter, transceiver, telephone and telegraph sections are housed in a welded metal equipment rack measuring 466 X 543 X 720 mm, which is fastened by means of shock absorbers to a bench area set up in the forward part of the van and the wall. The mains board is located on the bench in the left-hand forward section of the van.

The charging boards are located in the forward area of the van on the left and right walls. On the right wall of the van alongside the charging board is located a type RRT-31 regulator relay.

Fastened to the forward wall of the van are the line boards of the corresponding half-sets.

The power amplification section is attached to a special frame on a bench between the equipment racks.

Located along the left- and right-hand walls of the van are the battery cases as well as the containers for spare parts and accessories.

During relocations the charging units are fastened under the bench in the forward part of the van by means of special dowels with wing-nuts.

The equipment of the stationary model is installed on a bench of adequate size.

The intersectional connections are designed in the form of plug-and-socket connectors (internal rack assembly) and connector cables.

This design permits rapid assembly and removal of necessary equipment for operation and repair outside the van as well as rapid re-installation in the van.

A cast iron heater (stove) has been installed in a special compartment to the left in order to maintain a normal temperature inside the van during low temperature conditions. Communication between the van and the driver's cabin is effected by means of a talking device consisting of a crimped rubber tube and loudspeakers.

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For van illumination, in the rear section under the bench there is an overhead type illumination unit (ceiling model), the switch for which is located on the clock fastening clamp. The feed voltage for the bulb is fed, in the case of a-c mains powering, from the mains board, and in the case of battery powering, from the charging board. The voltage for the lamp is fed through a contact block located in the van door; when the door is opened, the contact block breaks the circuit and the bulb goes out.

Outside, on the left and right side of the van, are located input (lead-in) recesses (ports) on which there are two rows of numbered terminals to which the wire communication lines are attached. In addition, these recesses contain: a connector marked 127/220 for connecting the external a-c power mains, a connector marked 12+27 for connecting the battery charger cable, a block marked 12v for connecting a soldering iron or portable lamp and a terminal with a wing-nut for connecting a ground-line.

On the runners, on both sides of the van and on its forward wall, the antenna mast erectors are fastened by means of special brackets.

The whip antenna and matching device are installed on the roof of the van by means of a special insulator.

There are flanged openings in the upper forward section of the van for the antenna transmission lines.

Between the van floor and the chassis of the truck there is located a compartment for storing the antenna cases (with access from the door) and a compartment for the jointed masts (with access from the right and left side of the van).

2.

Antenna Unit

The station is equipped with antenna units which permit operation both from a fixed position and while in motion.

In a stationary position each halfset operates over an antenna-mast unit consisting of the following elements:

- A Crossed Yagi Antenna
- Transmission Lines
- Mast with Erector
- Mast Guys

A whip antenna is used for the operation of one of the half-sets of the station when in motion.

Crossed Antenna

The crossed antenna of the R-401M consists of two Yagi antennas fixed on a single boom and arranged perpendicularly one to the other (Fig. 4). If one of these antennas is used for transmission, the other serves as a receiving antenna.

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This type of crossed design for the receiving and transmitting antennas makes possible their location on a single common mast and provides rather high cross-talk attenuation between them (not less than 38 db). The high crosstalk attenuation between antennas makes possible simultaneous operation of the transmitter (power amplification section) and receiver with no reduction in the latter's sensitivity.

The Yagi antenna consists of a series of parallel metal dipoles located in one plane and fastened to a metallic directive boom (Fig. 15)*. One of the dipoles is active. This active dipole is fastened to the rod on insulators and is connected, by means of a transmission line (feeder), either to the receiver input or the transmitter output (Fig. 15)*.

The remaining or so-called passive dipoles are excited by the field of the active dipole and are attached to the boom without insulation.

In the antenna of the R-401M there are three passive dipoles. Passive dipole P, located behind the active dipole, is called the reflector. Passive dipoles $\Delta 1$ and $\Delta 2$ located in front of the active dipole, are called directors.

The distances between dipoles and their lengths are so chosen that their fields are added in phase in the direction of the directors. It is this which imparts to the Yagi antenna its directional properties. With a constant dipole length and inter-dipole distance, the directivity of a Yagi antenna is shown to good effect in a relatively narrow frequency band.

The balanced active dipole is joined to the coaxial transmission line through a matching device. Used as a matching device is a metal tube, the length of which equals one-quarter of the length of the radio wave (Fig. 16).

The internal surface of the tube and the metallic wire braiding of the transmission line form a quarter-wave short-circuited long line, the input impedance of which is very high at the point where the transmission line is connected to the active dipole. Because of the high input impedance of this line, the current fed from the transmitter over the feeder to the active dipole, or the current traveling from the active receiving dipole over the feeder to the receiver, is not dissipated into the metallic wire braiding of the transmission line.

As indicated above, in the R-401M the receiving and transmitting Yagi antennas have been combined into a single cross-shaped unit, having, in effect, a vertical and horizontal antenna (Fig. 4). The balancing devices of both antennas are located within the directive boom between the active dipole and the reflector. Since the vertical antenna is tuned to higher frequencies, its balancing device is somewhat shorter than that of the horizontal antenna.

The vertical antenna is tuned to operate in a frequency range of 65-70 Mc (88-154 fixed frequencies), while the horizontal antenna is tuned to operate either in a band of 60-65 Mc (21-87 fixed frequencies) or in a band of 66-68 Mc (101-127 fixed frequencies), this being achieved by means of replaceable dipoles.

* TN: Fig. 15 was apparently omitted inadvertently from the original Russian text.

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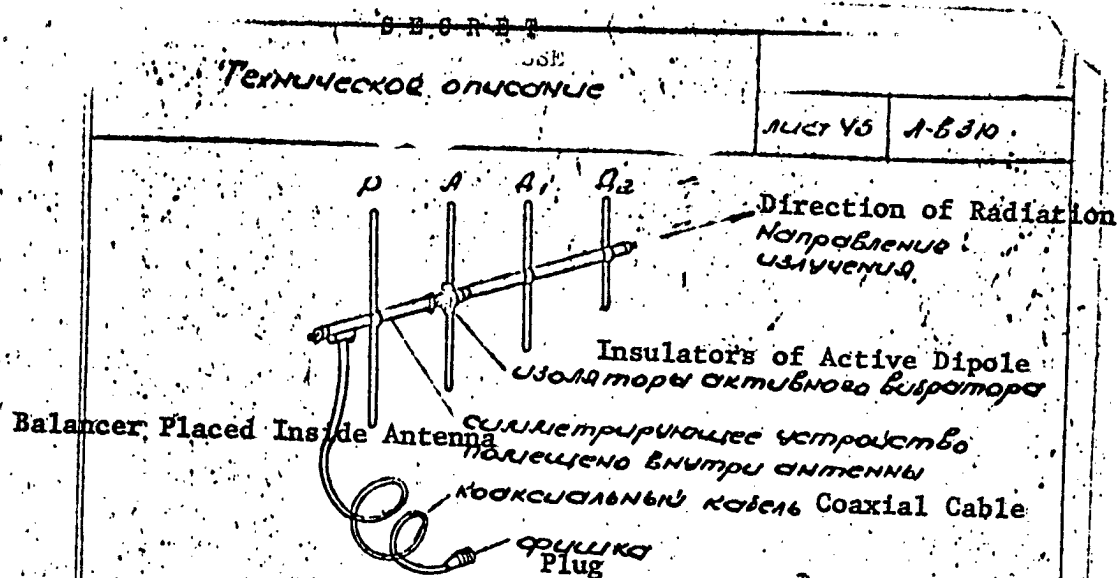


Рис. 15. Устройство антенны типа
волнового канала.

Fig. 15 Yagi Antenna Configuration

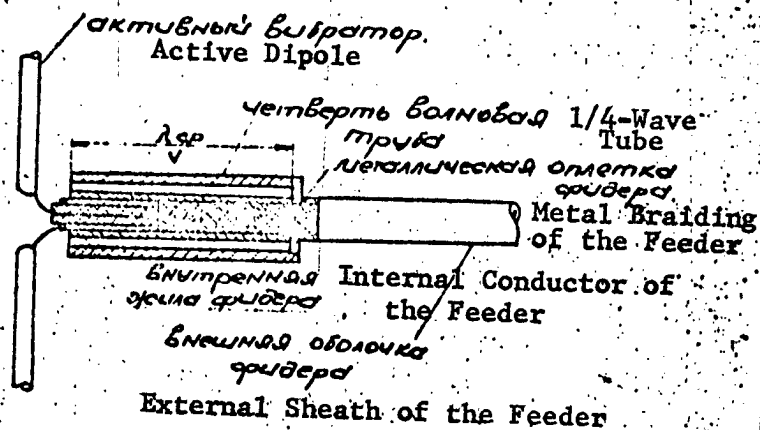


Рис. 16 Симметрирующее устройство

Fig. 16 Balancer

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All the dipoles of the antenna are removable and are fastened to the directive boom by means of special locks.

The dipoles of the vertical antenna have a white marking. When working with a reception and transmission frequency separation of 67 fixed frequencies (with the R-401M) dipoles marked in red are placed in the horizontal antenna; when working with a separation of 27 fixed frequencies (with the R-401) dipoles having a khaki-colored marking are placed in the horizontal antenna.

The plugs for connecting the transmission lines to the antennas are located at the bottom of the directive boom behind the reflectors. The vertical antenna plug has a white marking while the horizontal antenna plug has a khaki-colored marking.

On both ends of the directive boom there are fastening rings for connecting the slueing lines by means of which the antenna is oriented toward the correspondent.. The boom of the cross-shaped antenna of one half-set is fixed in its working position by means of a special holder on the upper end of a wooden insulator representing also the upper joint of the mast.

In the mobile state all antenna unit elements (boom with holder, dipoles and both transmission lines) are kept in a duraluminum case. Each station has two of these antenna cases. The latter are transported in a box located under the truck van and are removed from this container from the rear of the van.

The basic electrical characteristics of the antennas used in this station are given in Section 3, Chapter I.

Transmission Lines

The antennas, once set up on the mast, are connected with the receiver and transmitter of the station by means of type RK-1 high-frequency coaxial cables with a characteristic impedance of 75 ohms. Every half-set has two such cables, each 25 meters long.

At the ends of the cables are connecting plugs. The cables for vertical antennas have a white marking, while those for horizontal antennas have no marking. The cables are transported in the trunk of the vehicle or in packing cases.

When the R-401M is used under stationary conditions with its antennas set up on special high masts or local objects (multi-story buildings, towers, etc.), it is recommended that type RK-3 high-frequency coaxial cable (with the same characteristic impedance of 75 ohms) be used for the transmission lines. The length of RK-3 cable transmission lines may be considerably extended. RK-3 cable is not regularly assigned to the R-401M station.

Mast with Erector

Standard equipment with each station includes two telescopic masts and two erectors.

Each mast consists of nine joints. The upper mast joint is wooden, measuring two meters in length, and acts as an insulator. This is done in order to avoid distortion of the directional characteristics of the vertical antenna. The remaining

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eight joints of the mast consist of duraluminum tubes, 1.6 meters in length, each tube having a cylindrical tip on one end. By means of these tips or end pieces the mast joints are inserted one into the other.

The mast erector is comprised of two duraluminum joints similar to the joints of the mast. The joints are interlinked by means of a metal insert, on which is located the arresting mechanism for holding the raised mast and a pulley for guiding the winch cable. The winch is fixed to the lower joint of the erector and serves to facilitate the raising of the mast. Below, the mast has a support plate. Attached to the upper end of the topmost erector joint is a guide bushing (sleeve), through which the mast joints are run. The guide bushing has three lugs for fastening the lower tier of the mast guides. For convenience in setting up the antenna, there are rungs on the erector.

The mast is erected by extending its joints from below with the erector mechanism. The full height of the mast, with all nine joints expanded, is 14.5 meters.

The mast is held steady in the vertical position by three tiers of guys. Each tier consists of three guys which diverge downward toward the pegs at an angle of 120° . The guy pegs are driven into the ground at a distance of 8m from the foot of the mast, forming the apices of an equilateral triangle (Fig. 47). In its erected position, the mast is capable of revolving around its own axis.

In the mobile state the mast joints and the upper joints of the erector devices are transported in a metal box located under the truck van. The joints are removed from the box from the right side of the van. Both erector devices, together with the upper wooden joints of the mast, are fastened to the forward wall of the van on both sides of the driver's cabin. Winches and arresting mechanisms for the erectors are covered by protective tarpaulins (Fig. 1).

Mast Rigging

The mast rigging consists of nine guys with the parts necessary for fastening them to the mast, three summer-type long metal pegs, three winter-type short metal pegs and a sledgehammer.

All guys are manufactured of steel cable two millimeters in diameter. For convenience in setting up the mast the lower ends of the guys are taken up by means of a lagline and are equipped with wooden cleats by means of which the length of the guys can be adjusted. At the end of the guys are snap hooks or crooks for fastening them to the mast and to the pegs. For convenience in assembling and disassembling the guys there are three special metal forks with handles.

In the mobile state the rigging for each mast is packed separately and stored in the right-hand locker inside the truck van.

Whip Antenna

For operation of the station while in motion a whip antenna having circular radiation in the horizontal plane is employed. The antenna is in the form of a half-wave vertical rod 2.18 meters in length. The metal lining of the van roof is used as the balancing capacitance.

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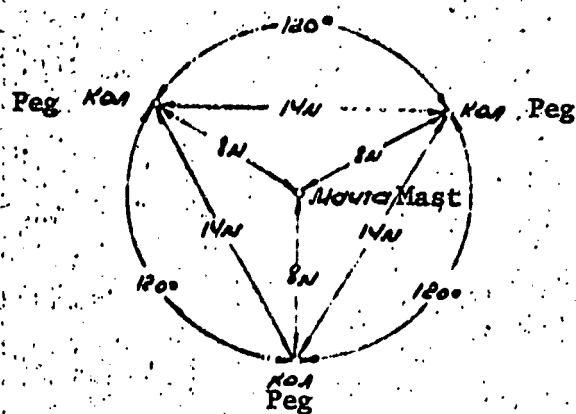


Рис. 17 Расположение колеб для оттяжек.

Fig. 17 Arrangement of the Guy Pegs.

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The whip antenna is attached to the roof of the van by means of a rubber insulator which permits it to bend, should it accidentally come into contact with external obstacles. If necessary, the rod forming the whip antenna may be removed from the insulator. Simultaneous receiver and transmitter operation over the whip antenna is possible only through use of the frequency filter section. The antenna is connected with the frequency filter section by means of a type RK-1 coaxial cable. One end of this cable is connected to the whip base through a matching device located between the roof and ceiling of the van. The other end of this cable is equipped with a plug for connection to the frequency filter section. The matching device consists of an induction coil, capacitance and short-circuited long line consisting of a type RK-1 coaxial cable, 54.5 cm in length (Fig. 18).

The traveling-wave ratio of the whip antenna is not less than 0.45.

3.

Frequency Filter Section

The frequency filter section is designed to permit simultaneous working of the receiver and transmitter over a single antenna.

The frequency filter section provides for single-antenna operation with two frequency separation values between reception and transmission:

- in the 60-70 Mc band, with a separation of 5 Mc (67 fixed frequencies);
- in the 66-70 Mc band, with a separation of 2 Mc (27 fixed frequencies).

The first mode is designed for operation with another R-401M station. The second mode provides for communication between an R-401M and an R-401 (or R-403) station. Transition from one mode to the other is effected by means of the switches marked "PA3HOC BO H" ("FREQUENCY SEPARATION").

The frequency filter section has the following electrical characteristics: the reduction of the signal traveling from the transmitter to the antenna, or of the signal traveling from the antenna to the receiver, does not exceed 3 db, while at the same time, the frequency filter section provides not less than 50-db attenuation of the transmitter signal at the receiver input. An attenuation in this order permits simultaneous operation of the transmitter (power amplification section) and receiver over the same antenna.

Design of the Section

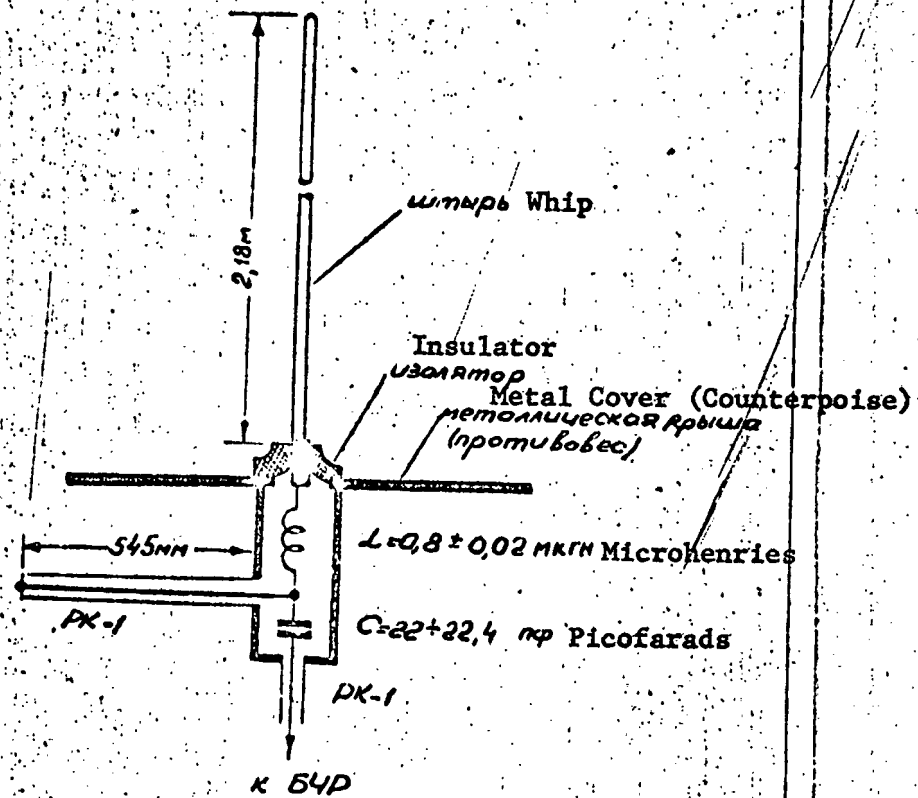
The basic feature in the design of the frequency filter section is the forward panel of cast Silumin*, to which are fastened, by means of screws, the cast Silumin filter frames of the left and right arms. In terms of their design, the filter frames of the left and right arms are of identical type and are divided into two compartments, in which are located the circuit elements.

* TN: A silicon-aluminum alloy.

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To the Frequency Filter Section

Рис. 18 Согласующее устройство
штыревой антенны.

Fig. 18 Whip Antenna Matching Device

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Figs. 19 and 20 show an external view of the frequency filter section. A single control is used to tune the variable capacitors of the circuits of each filter. The gear wheels of the variable capacitors and the vernier/dial devices are located beneath the section in a horizontal recess.

The filters are individually calibrated for operation with a reception and transmission frequency separation of 27 and 67 fixed frequencies.

The case housing the frequency filter section is manufactured of light sheet duraluminum and has in its forward wall an opening through which an adapter block may be inserted for the dial illumination lamps.

The dimensions of the frequency filter section in its case are 93 X 370 X 290 mm. The section weighs 5.5 kg.

Circuitry of the Section

The frequency filter section is a system of high-frequency filters which form two arms or branches (Fig. 21). The filter of the left arm can be continuously tuned to pass a signal in a band of 60-65 Mc (21-87 fixed frequencies) with a 5-Mc separation in reception and transmission, or to pass a signal in the 66-68 Mc band (1-27 fixed frequencies) with a 2-Mc separation. The filter of the right arm can be continuously tuned to pass a signal in the 65-70 Mc band (88-154 fixed frequencies) with a 5-Mc separation, or to pass a signal in the 68-70 Mc band (28-54 fixed frequencies) with a 2-Mc separation (Fig. 21). The receiver or transmitter is connected to the right or left arm of the frequency filters depending on their working frequencies.

The block diagram of the frequency filter section is shown in Fig. 22. The filter of the left arm consists of a system of two parallel circuits of the second type. As is well known, a parallel circuit of the second type possesses two forms of resonance:

- parallel resonance on a frequency

$$f_o = \frac{1}{2\pi \sqrt{(L_5 + L_4) \cdot C_5}} ;$$

- series resonance on a frequency

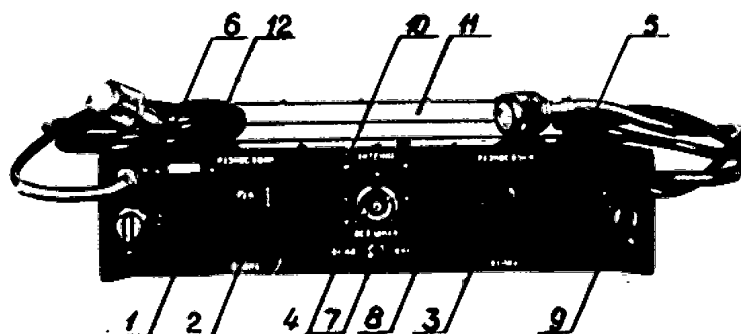
$$f_p = \frac{1}{2\pi \sqrt{L_5 C_5}} .$$

On parallel resonance frequencies the circuits have a very high impedance - many times higher than the characteristic impedance of the RK-1 cable (75 ohms) - and exercise no noticeable shunting effect on the signals passed in the lower half of the band.

On the other hand, on the series resonance frequencies these circuits show a very small impedance. Since in the case of a circuit of the second type the series resonance frequency is always greater than the parallel resonance frequency,

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**FIG. 19 - Frequency Filter Section**

1. Filter Tuning Controls
2. Dial Windows
3. Frequency Separation Switches
(B_1 , B_2 , B_3 , B_4)
4. Antenna Cable Connecting Plug
5. HF Cable of Right Arm
6. HF Cable of Left Arm
7. Dial Illumination Switch (B_5)
8. Dial Illumination Lamp Receptacles
9. Catch for Attaching Section to its Case
10. Forward Panel of Section
11. Case
12. Identification Shield

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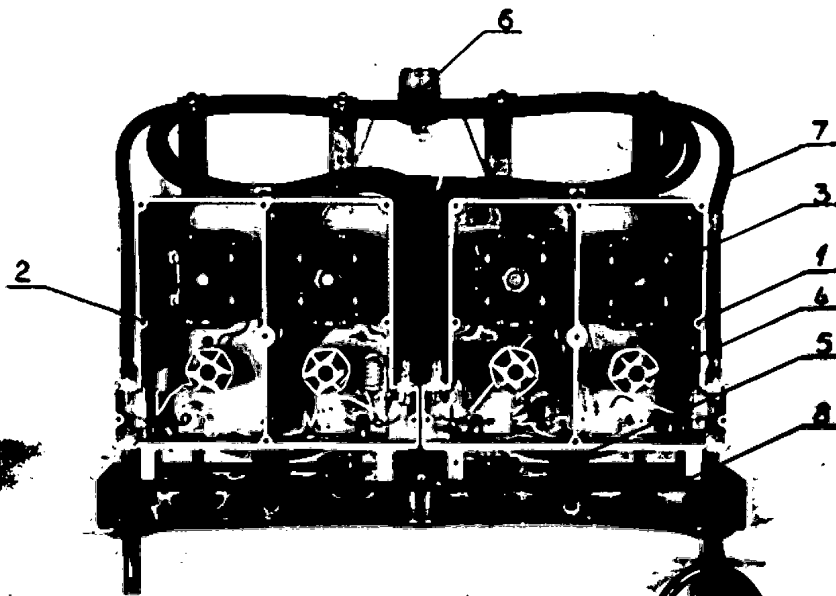


FIG. 20 - View of Frequency Filter Section from Above without Case and Screen Covers

1. Frame of Right Arm
2. Frame of Left Arm
3. Variable Capacitors
4. Inductance Coils
5. Frequency Separation Switches
6. Adapter Block for Illuminating Lamp Power Supply
7. Quarter-Wave Cables Type RK-1
8. Forward Panel

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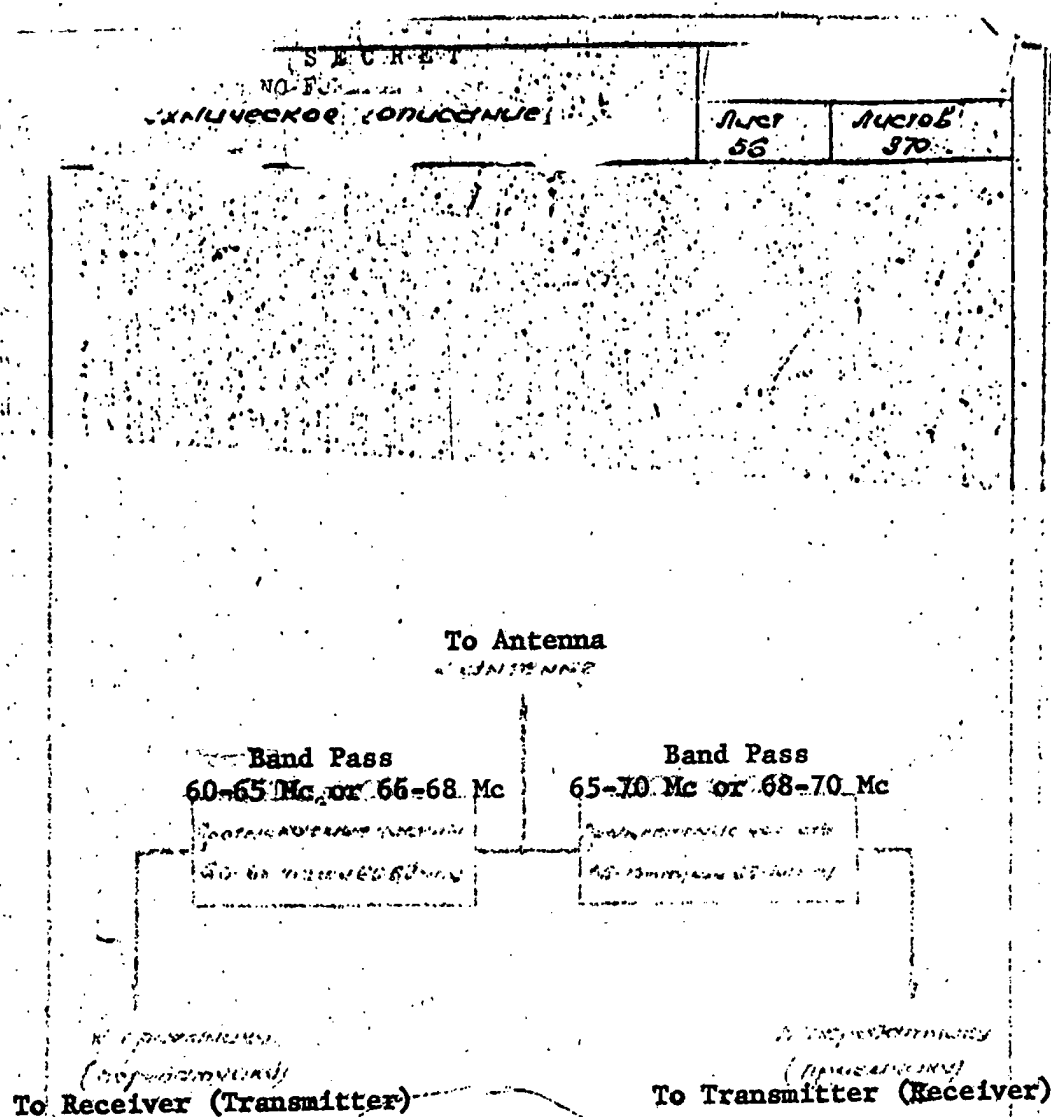


Fig. 21 Block Diagram of Frequency Filter Section

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thus the circuits of the left arm will in actuality represent a short-circuit for the signals of the upper half of the band.

In this way, the circuits of the left arm pass almost without losses the signals of the lower half of the band of the station and hold back the signals of the upper half of the band.

In order that the circuits of the left arm not shunt those of the right arm, which are tuned to pass signals of the upper half of the band, the left arm circuits are connected to the antenna over an RK-1 cable, the electrical length of which is equal to one-quarter of the mean wavelength of the upper part of the band

$\frac{\lambda_{\text{mean up.}}}{4}$. In this case the quarter-wave line, short-circuited at the end by series circuit L5-C5, has a very high input impedance on the frequencies of the upper half of the band at the point where the antenna is connected.

In order to achieve in the left arm maximum attenuation for signals of the upper half of the band, the circuits of this arm are also interconnected by means of RK-1 cable, the electrical length of which equals one-quarter of the mean wavelength of the upper part of the band.

The right arm filter is comprised of a system of two parallel circuits of the third type, which also possess two kinds of resonance:

- parallel resonance on a frequency

$$f_o = \frac{1}{2\pi \sqrt{\frac{C_1 \cdot C_2}{C_1 + C_2} + L_1}}$$

- series resonance on a frequency

$$f_p = \frac{1}{2\pi \sqrt{L_1 C_1}}$$

For signals of the upper half of the band these circuits are tuned to parallel resonance and have no noticeable shunting effect. Since the series resonance frequency of circuits of the third type is always less than the frequency of parallel resonance, the circuits of the right arm will practically represent a short-circuit for the signals of the lower half of the band.

In this way, the circuits of the right arm pass almost without losses the signals of the upper half of the band and hold back the signals of the lower half.

The circuits of the right arm do not shunt those of the left arm which pass signals of the lower half of the band. The right arm circuits are connected to the antenna over an RK-1 cable, the electrical length of which equals one-quarter of the mean wavelength of the lower half of the band $\frac{\lambda_{\text{mean low}}}{4}$. In this case,

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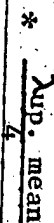


Fig. 22 Basic Diagram of Frequency Filter Section

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the quarter-wave line, short-circuited at the end by series circuit L2-C4, has a very high input impedance on the frequencies of the lower half of the band at that point where the antenna is connected.

In order to achieve in the right arm maximum attenuation for signals of the lower half of the band, the circuits of this arm are also interconnected by means of RK-1 cable, the electrical length of which equals one-quarter of the mean wavelength of the lower part of the band $\frac{\lambda_{\text{mean low}}}{4}$. Because of these quarter-wave

long-line segments, short-circuited by means of series circuits L2-C4 and L5-C5, at the connection point of the cable running to the antenna there will be practically no dissipation of energy to the left arm on frequencies of the upper half of the band, and to the right arm on frequencies of the lower half of the band of the station.

In the diagram shown in Fig. 22 the position of switches "B" is shown for a case of a frequency separation of 67 fixed frequencies.

When working with a frequency separation of 27 fixed frequencies, inductances L3 and L6 are additionally connected to the circuits of the left arm, while inductances L9 and L10 are disconnected from those of the right arm.

4.

Transceiver Section

The transceiver section contains the following basic components: UHF transmitter, intermediate frequency amplifier, transmitter feed element, receiver feed element. Description of these components is given below. Charts showing the constant voltages and resistances of the transceiving unit are given in Appendix 3.

Design of the Section

The basic feature in the design of the transceiver section is the cast Silumin mounting rack to which are fastened, by means of screws, the cast Silumin forward panel and the individual components of the section. An external view of the transceiver section is given in Figs. 23, 24, 25 and 26.

The individual components of the section are mounted in independent cast Silumin frames, divided into a number of compartments.

The transceiver section is so designed as to permit replacement of all tubes from above the mounting rack.

The section is enclosed in a light duraluminum housing which has in its rear wall openings for connecting plugs and guide bushings, on its right wall a flanged opening for access to the trimmer for receiver frequency correction, and on the left wall a flanged opening for access to the trimmer for transmitter frequency correction and to the potentiometer for automatic frequency control (AFC) adjustment. The dimensions of the transceiver section in its housing are 220 X 380 X 425 mm. The section weighs 26 kg.

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Transmitter

The transmitter is installed in a separate cast Silumin frame divided into a number of compartments (Fig. 26, No. 1) which contain the individual circuit components of the transmitter. Access to the latter is afforded without the need of removing the transmitter frame from the section rack.

Fig. 27 shows a block diagram of the radio transmitting equipment. All the high-frequency circuits of the transmitter are tuned by means of special cylindrical variable capacitors. The stator (immovable) and rotor (movable) cylinders of variable capacitor C38 of the master oscillator are manufactured of Invar* in order to increase the temperature frequency stability. In the remaining high-frequency transmitter circuits the stators of variable capacitors C1, C4, C14 and C25 are made by annealing a layer of silver to the surface of the ceramic forms of coils L1, L2, L5 and L7, while the rotors, which move inside the form along its axis, are made of Invar (Fig. 28).

The windings of all the circuit coils L1, L2, L5, L7 and L12 are also made by annealing silver to the ceramic form.

The tuning of all circuits (longitudinal movement of all rotors) is accomplished simultaneously by mechanical actuators through a single control for frequency tuning and adjustment. The transmitter dial is attached directly to the tuning mechanism shaft. The dial visor is located on a vernier device which is attached to the forward panel of the section. The rotational movement of the dial is converted into a forward motion of the rotor of the master oscillator trimmer by means of a helical gear, while the forward motion of the circuit rotors is provided by means of a cam gear.

The working condition of each transmitter tube is checked by means of indicator device ИИ and its switches B2 and B3 which are located on the forward panel of the section (Fig. 23, Nos. 5 and 6). All the electric power circuits and certain of the indicator circuits of the transmitting unit pass through noise-suppression filters consisting of inductances L15-21 and duct capacitors C59-65.

Master Oscillator

The master oscillator operates with a type 12Zh1L (Л3) tube and is designed with a two-circuit arrangement having electron coupling (Fig. 29). The two-circuit scheme makes it possible to achieve a high degree of frequency stability in the tube oscillator. The master oscillator provides high-frequency oscillations in a 60-70 Mc band. The frequency of the generated oscillations is determined by grid circuit L12-C38. This circuit has a high Q and good reference qualities. Circuit coil L12 is made by annealing silver to the surface of the ceramic form and is enclosed in a hermetically sealed screen to reduce the effect of moisture on this circuit (Fig. 29).

The internal oscillator uses a triode system with capacitance feedback and grounded plate. The screen grid of tube Л3 is used as the plate, which is grounded for high-frequency currents by means of capacitor C28. The interelectrode capacitance of the tube in this scheme is shunted by capacitors C35 and C36. Moreover,

* TN: An iron-nickel alloy.

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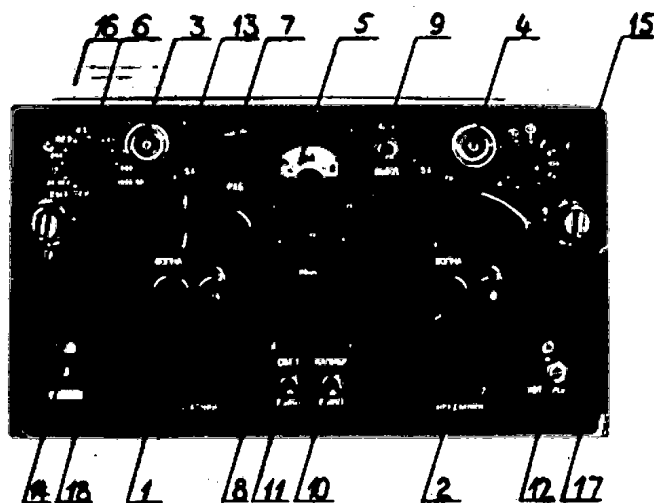


FIG. 23 - Transceiver Section

- | | |
|--------------------------------------|--|
| 1. Dial-Vernier Devices | 10. Crystal Calibrator Switch (B_5) |
| 2. Dial Setters | 11. Dial Illumination Switch (B_6) |
| 3. Transmitter Output Plug | 12. Transmission Level Adjusting Potentiometer R_7 |
| 4. Receiver Input Plug | 13. Fuses ($\Pi p1-\Pi p2$) |
| 5. Indicator Device | 14. Opening for Transmitter Output Circuit Tuning |
| 6. Indicator Switches (B_2, B_3) | 15. Catch for Attaching Section to its Case |
| 7. Operating Mode Switch (B_4) | 16. Case |
| 8. Power Selection Switch (B_1) | 17. Forward Panel |
| 9. AFC Switch (B_7) | 18. Identification Shield |

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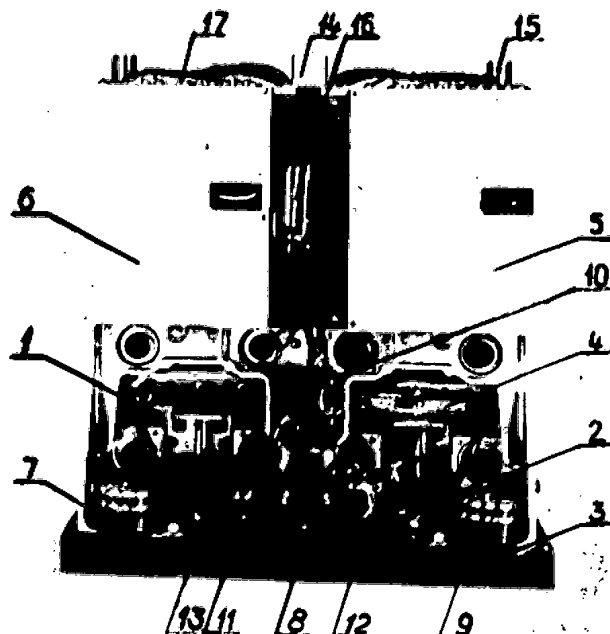


FIG. 24 - View of Transceiver Section from Above with Case Removed

- | | |
|-------------------------------------|------------------------------------|
| 1. Transmitter Element | 10. Power Selection Switch |
| 2. Element of Receiver HF Amplifier | 11. Operating Mode Switch |
| 3. Forward Panel | 12. AFC Switch |
| 4. Tuning Mechanism | 13. Fuses |
| 5. Receiver Feed Element | 14. Adapter Connecting Block |
| 6. Transmitter Feed Element | 15. Guide Bushings |
| 7. Section Frame | 16. Single-Channel Operation Relay |
| 8. Indicator Device | 17. Feed Element Contacts |
| 9. Indicator Switches | |

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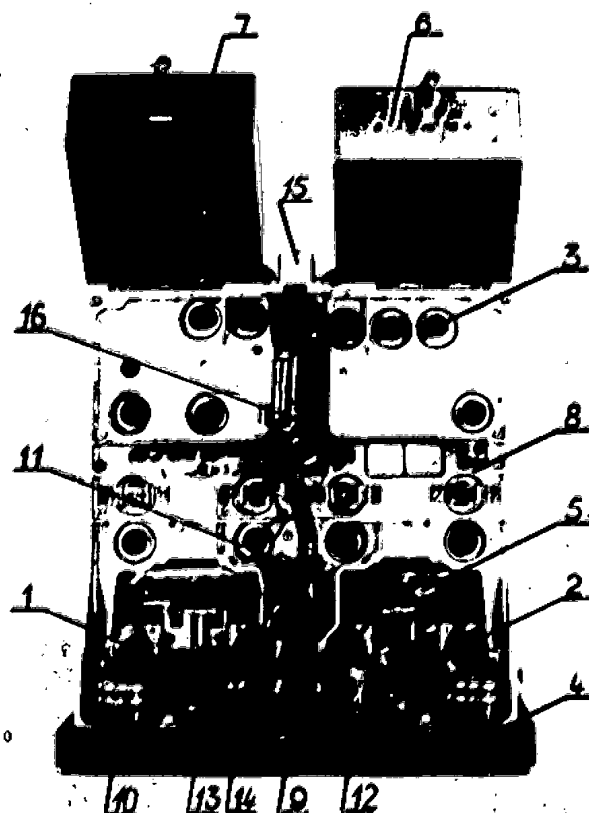
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FIG. 25 - View of Transceiver Section with Case Removed
(Feed Elements Eliminated)

- | | |
|----------------------------------|------------------------------------|
| 1. Transmitter Element | 9. Indicator Device |
| 2. Receiver HF Amplifier Element | 10. Indicator Switches |
| 3. Receiver IF Amplifier Element | 11. Power Selection Switch |
| 4. Forward Panel | 12. AFC Switch |
| 5. Tuning Mechanism | 13. Fuses |
| 6. Receiver Feed Element | 14. Operating Mode Switch |
| 7. Transmitter Feed Element | 15. Adapter Connecting Block |
| 8. Section Frame | 16. Single-Channel Operation Relay |

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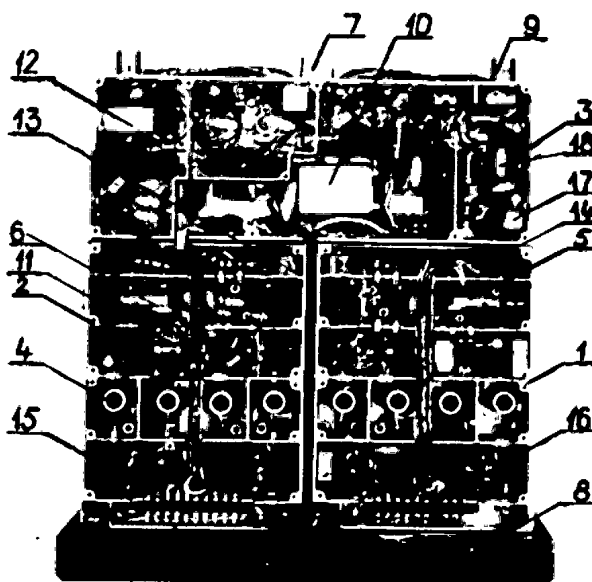
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FIG. 26 - View of Transceiver Section from Below
with Case Removed (Screen Covers Removed)

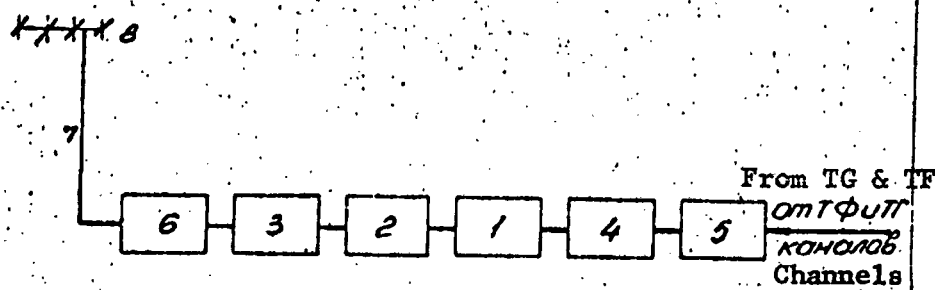
1. Transmitter Element
2. Receiver HF Amplifier Element
3. Receiver IF Amplifier Element
4. HF Circuits
5. Trimmer for Transmitter Frequency Correction
6. Trimmer for Receiver Frequency Correction
7. Adapter Connecting Block
8. Forward Panel
9. Guide Bushings
10. Receiver Output Transformer
11. Calibrator Crystal
12. Crystal of Receiver Second Converter
13. Receiver Noise-Suppression Filter Compartment
14. Transmitter Noise-Suppression Filter Compartment
15. Adapter Block of Receiver HF Amplifier Element
16. Transmitter Element Adapter Block
17. Receiver Output Level Adjusting Potentiometer
18. AFC Adjusting Potentiometer

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Скоп описание

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1. Задаточный генератор, Master Oscillator
2. Промежуточный каскад, Intermediate Stage
3. Усилитель мощности, Power Amplifier
4. Частотный модулятор, Frequency Modulator
5. Групповой модуляционный усилитель, Group Modulation Amplifier
6. Фильтр подавления второй гармоники, 2nd Harmonic Suppression Filter
7. Высокочастотный фидер, HF Transmission Line
8. Антенна, Antenna

Рис. 27. Блок-схема передающего устройства.

Fig. 27 Block Diagram of Transmitting Unit

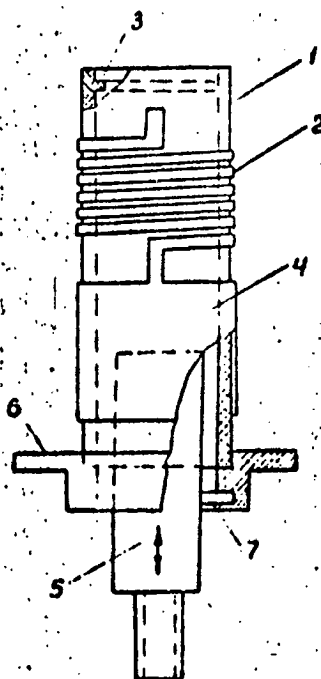
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- 1. Керамический корпус. Ceramic Frame
- 2. Витки контурной катушки. Circuit Coil Windings
- 3. Кольцо для подстройки индуктивности. Inductance Tuning Ring
- 4. Статор. Stator
- 5. Ротор. Rotor
- 6. Держатель корпуса. Frame Holder
- 7. Пружинное заземление ротора. Rotor Spring Grounding

Рис 28. Устройство высокочастотного контура.

Fig. 28 High Frequency Circuit

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these capacitors are connected to inductance coil L12 in series with variable capacitor C38. This capacitor arrangement provides loose coupling of the tube with the circuit and low initial capacitance for the internal circuit. This, in turn, provides rather high frequency stability in the face of feed voltage fluctuations for tube J3 .

Capacitors C35 and C36 are, at the same time, thermo-compensating elements (the temperature coefficient of capacitance of these capacitors is negative), which enhances the temperature frequency stability of the master oscillator.

Trimmer C37 is used to correct the frequency of the transmitter when replacing the J3 tube of the master oscillator and the J4 tube of the frequency modulator.

In the master oscillator circuit the cathode of tube J3 is at high-frequency potential with respect to ground. Consequently, the cathode and filament of the tube are insulated from the ground for high-frequency by means of chokes L9, L10 and L11. Chokes L9 and L10 are wound on a single common form.

Capacitors C30, C31, C32, C33 and C34 are blocking capacitors. Resistance R17 serves to create an automatic bias on the control grid of tube J3 through the grid current of the oscillator.

In order to develop effective power in the plate circuit, circuit L7-C25 is connected. Design-wise, this circuit is contained in a separate compartment of the frame. This circuit is coupled with the grid circuit through the common electron stream of tube J3 . The plate circuit is connected in a parallel feed arrangement. Consequently, this circuit is connected to the plate of tube J3 through two (because of design considerations) isolating capacitors C22 and C24, while the positive plate voltage is fed to tube J3 through choke L8.

Resistor R12 shunts the circuit, which lowers the driving amplitude of tube 2 to the necessary value and reduces the effect of intermediate amplification, when its operational mode changes, on the master oscillator frequency. Resistors R14 and R13 lower the voltage fed to the plate and screen grid of the tube. Capacitor C29 blocks.

Proper operating condition of the master oscillator tube is indicated by the value of the cathode current which, having passed through resistor R16, causes a voltage drop in that resistor. This voltage is fed through resistor R15 and switch B3 to the indicator device located on the front panel of the section.

Intermediate Amplifier

The intermediate amplifier uses a 12Zh1L tube (J2) and is designed in a parallel feed arrangement (Fig. 30). This amplifier provides the necessary driving voltage for the power amplifier (transmitter output stage). The presence of an intermediate amplifier makes it possible to employ the master oscillator tube under light load, thus enhancing its frequency stability (Fig. 30).

The bias on the control grid of tube J2 is formed through the grid current flowing through resistor R10.

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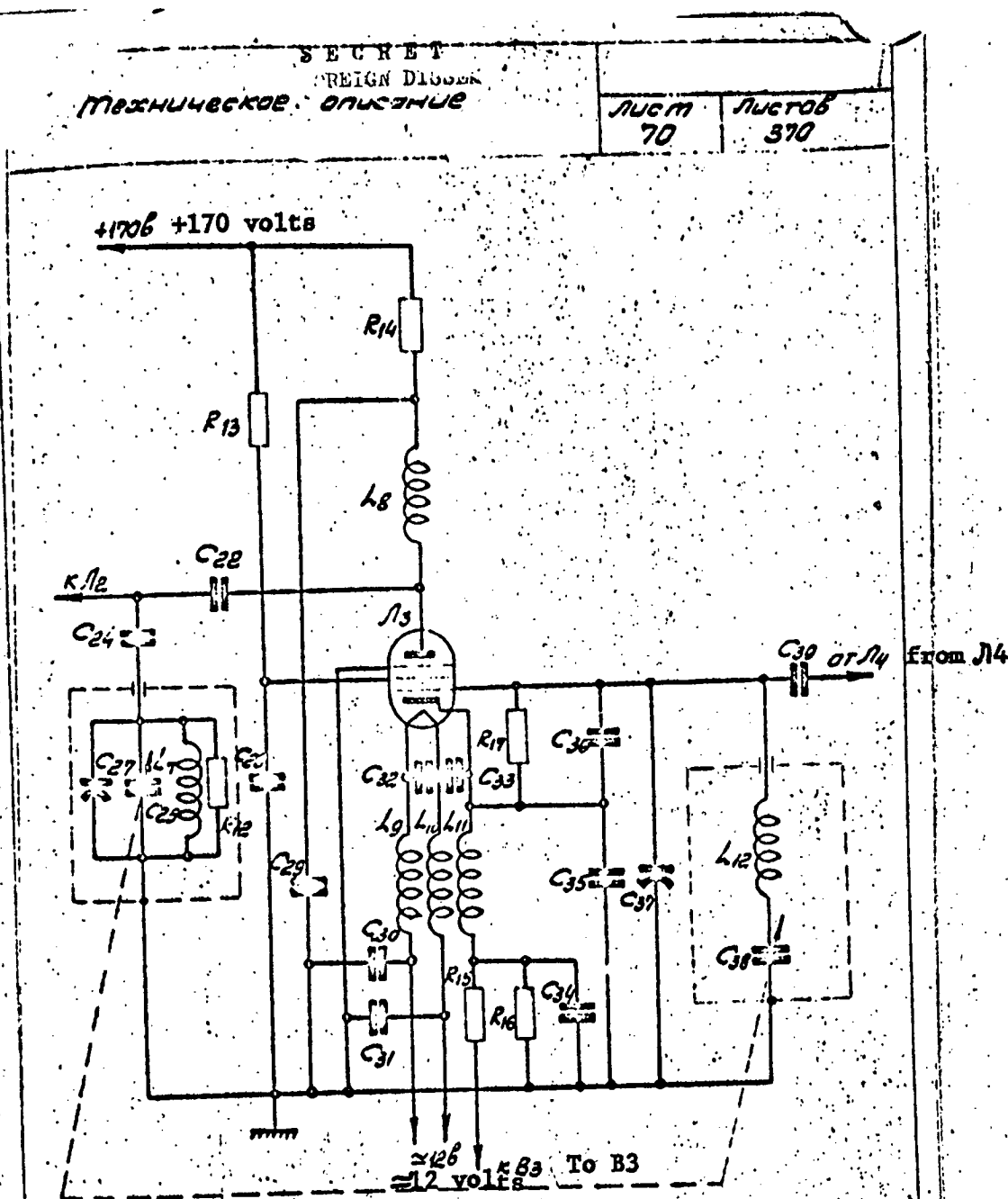


Рис. 29

Схема задающего генератора передатчика

Fig. 29 Diagram of Master Oscillator of the Transmitter

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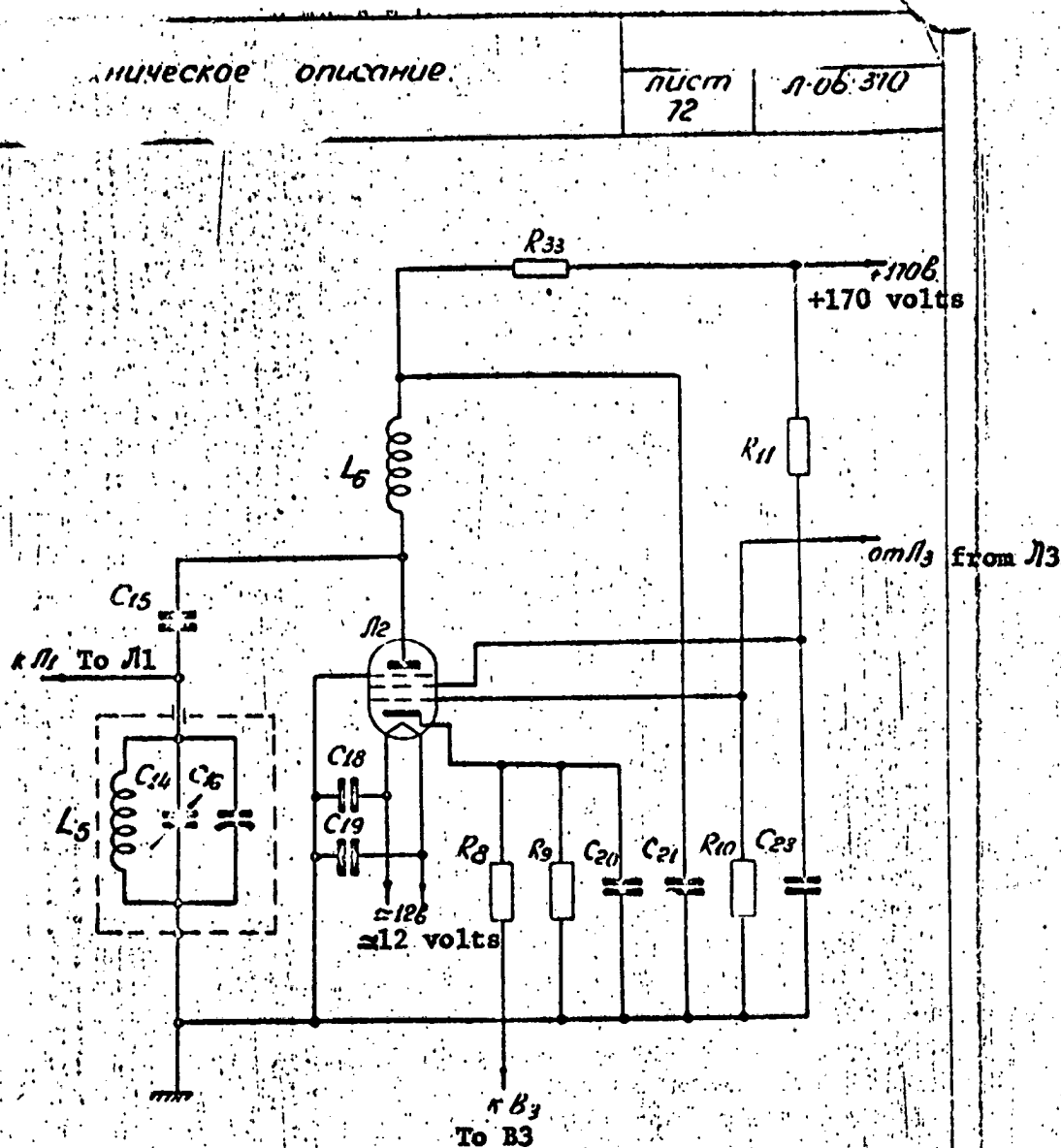


Fig. 30 Diagram of Intermediate Stage of Transmitter

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The purpose of the remaining components of the intermediate amplifier is similar to that of the components of the master oscillator and power amplifier.

Power Amplifier

The power amplifier (transmitter output stage) operates with a 12P17L tube ($\mathcal{M}$) and has a complex circuit arrangement with parallel feed (Fig. 31). Plate circuit L2-C4 is tightly coupled with tube $\mathcal{M}$. Trimmer C6, the control for which has been remoted to a slot on the front panel of the section (Fig. 23, No. 14), is used for tuning the circuit when the output stage tube is replaced (Fig. 31).

There is fixed autoinductive coupling of the antenna with the plate circuit. The power fed to the antenna transmission line with rated feed voltage is 2.5 watts.

The presence of oscillations at the transmitter output is checked by means of germanium diode $\Delta 1$ connected to the transmitter output through low-value capacitor C2 (1.5 micromicrofarads). The current rectified by this detector is fed through resistor R1, choke L18, trimmer capacitor C62 and switch B2 to the indicator device located on the front panel of the section. C3 is a blocking capacitor.

Combined bias is fed to the control grid of the output stage tube. From voltage divider R4-R5 the fixed negative bias in the order of 7.3 volts is fed through choke L4. The presence of this fixed bias limits the plate current of tube $\mathcal{M}$ if there is no excitation for any reason. If there is excitation, the grid current of tube $\mathcal{M}$, passing through resistor R4, also provides automatic bias. The resultant bias on the control grid of tube $\mathcal{M}$ relative to its cathode (frame) in the working mode is minus 15 volts.

To the suppressor grid of the output stage tube there is fed through capacitor C65, choke L21 and resistor R7 a small positive potential (approximately 12 volts) relative to the tube cathode (frame).

Proper operating condition of the output stage tube is indicated by the value of the cathode current which, having passed through resistor R3, causes a voltage drop in that resistor. This voltage is fed through resistor R2 and switch B3 to the indicating device located on the front panel of the section. Capacitors C7, C8, C9, C10, C11, C12 and C26 are blocking capacitors; that is, they short-circuit the corresponding points of the circuit for high-frequency currents.

Filter

In order to suppress the current of the doubled frequency (current of the second harmonic) which arises during the process of amplification of the fundamental frequency current, a filter is placed at the transmitter output. This filter is in the form of a series circuit L1-C1 (Fig. 31) operating in the 120-140 Mc band. It is well known that a series circuit at resonance frequency has low impedance. Because of this the transmitter output is practically short-circuited for the current of the doubled frequency, and the second harmonic current does not reach the antenna. Variable capacitor C1 of this filter is coupled with the remaining variable capacitors of the transmitter.

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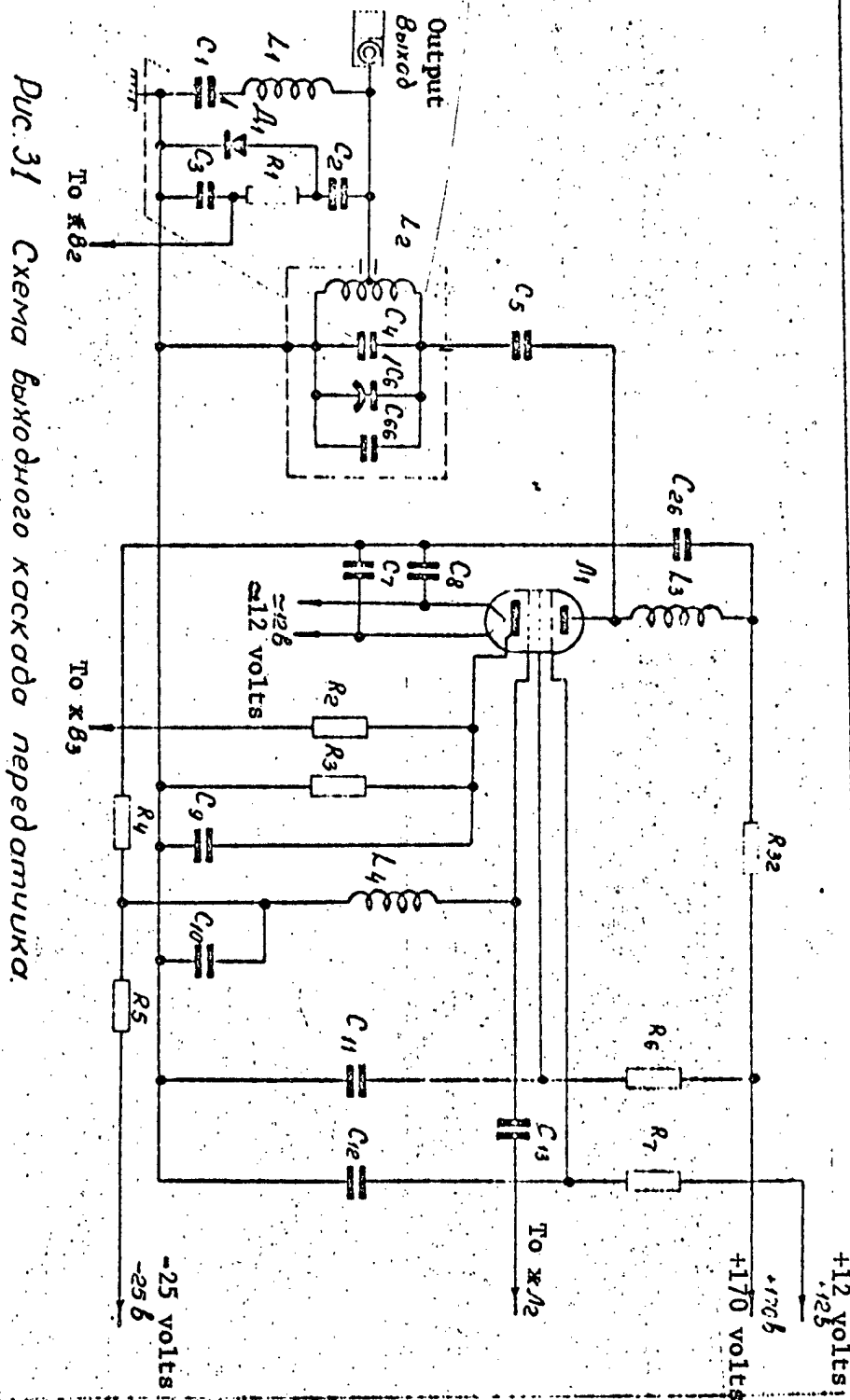


Рис. 31 Схема выходного каскада передатчика.

Fig. 31 Diagram of Output Stage of Transmitter

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Frequency Modulator

The frequency modulator consists of a type 12Zh1L (Fig. 32, tube $\mathcal{N}4$), operating in the triode mode (the screen and suppressor grids of this tube are connected to the plate) (Fig. 32).

The transmitter master oscillator frequency is modulated by the change in the dynamic input capacitance of frequency modulator tube $\mathcal{N}4$. When the cathode current of this tube passes through resistor R20, a voltage drop is caused in this resistor, and an automatic negative bias (in the order of 5 volts) relative to the tube cathode is fed to the control grid of tube $\mathcal{N}4$ through resistor R18 and choke L13. The electrons, departing the cathode of the tube under the influence of the negative potential of the control grid, form an electron cloud around the cathode. In addition to the static input capacitance of the tube, this electron cloud causes the occurrence of a dynamic input capacitance which is sensitive to the feed voltages.

If, in addition to the constant negative potential there is fed to the control grid of tube $\mathcal{N}4$, from the modulation amplifier (tubes $\mathcal{N}5$ and $\mathcal{N}6$) through capacitor C44 and high-frequency choke L13, an alternating low-frequency modulating voltage, then, as the negative potential increases on the control grid, the electron cloud will be compressed closer to the cathode and the dynamic input capacitance of the tube will decrease. On the other hand, if the negative potential decreases on the control grid the electron cloud will approach the grid and the dynamic input capacitance of the tube will increase.

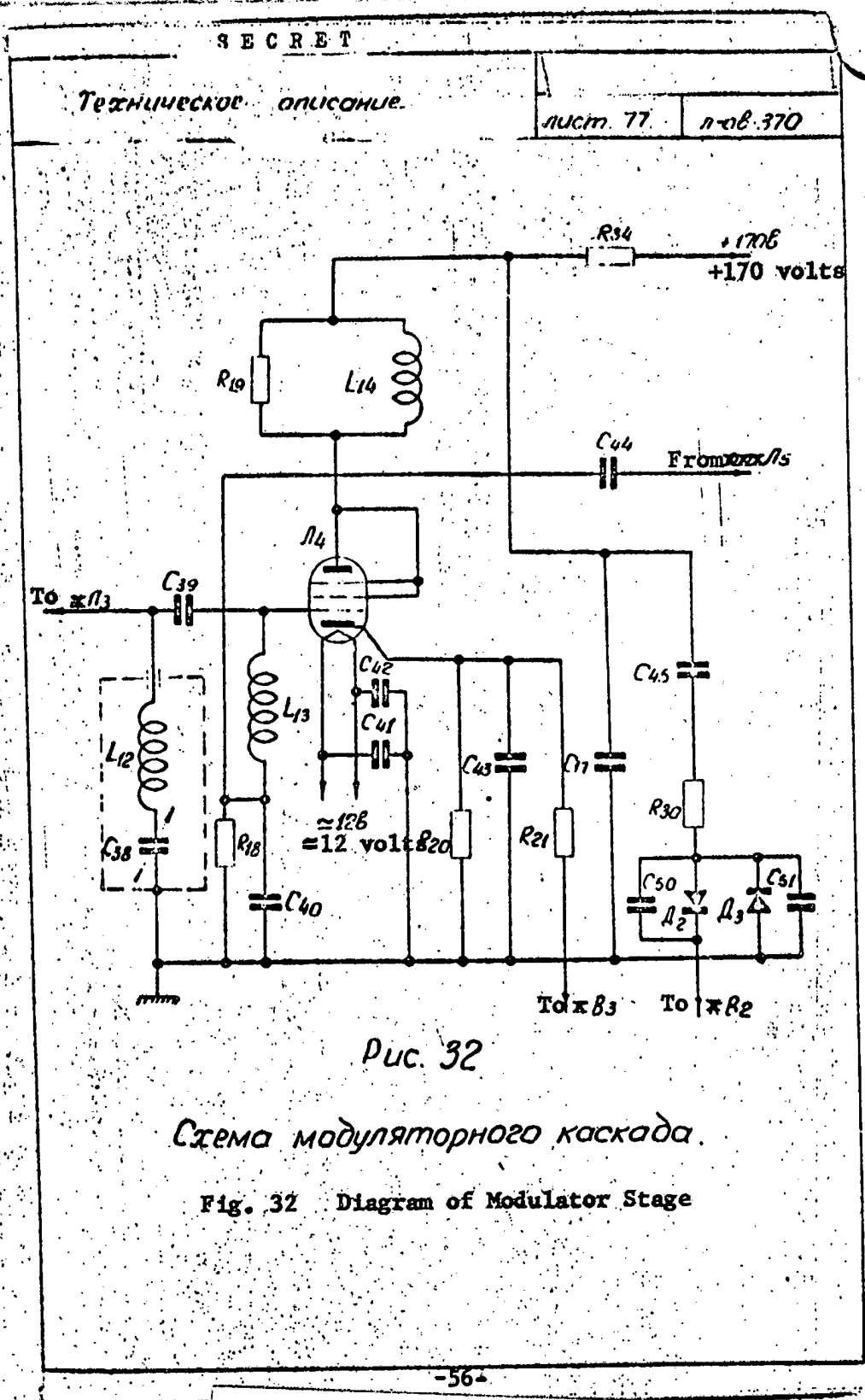
The control grid of tube $\mathcal{N}4$ of the frequency modulator is connected through capacitor C39 to oscillatory grid circuit L12-C38 (Fig. 32). As the dynamic input capacitance of tube $\mathcal{N}4$ changes under the influence of the low-frequency variable modulating voltage, the sum capacitance of the grid circuit of master oscillator C0 will also change. This causes a change in the frequency of the master oscillator according to the change of the modulating voltage; that is, the master oscillator is frequency-modulated.

Connected to the plate circuit of modulator tube $\mathcal{N}4$ is a parallel circuit formed by choke L14 and capacitance C (the capacitance of the tube cathode to the frame, the wiring capacitance and the stray capacitance of choke L14). The resonance frequency of circuit L14-C is close to the upper frequency of the working band. The circuit is shunted by low resistor R19. The inclusion of this circuit equalizes the frequency deviation of the master oscillator over the band. The transmitter modulation is monitored in the following way: from resistor R34 the low-frequency modulating voltage passes through isolating capacitor C45 and resistor R30 to germanium diode $\Delta 2$ with which there is connected in series (by means of switch B2) indicator device $\mathcal{N}1$ located on the front panel of the section. Germanium diode $\Delta 3$ is inserted in order to create a circuit of the rectified current direct component through the indicator device. The frequency modulation percentage of the master oscillator is determined by the magnitude of the indicator arrow excursion.

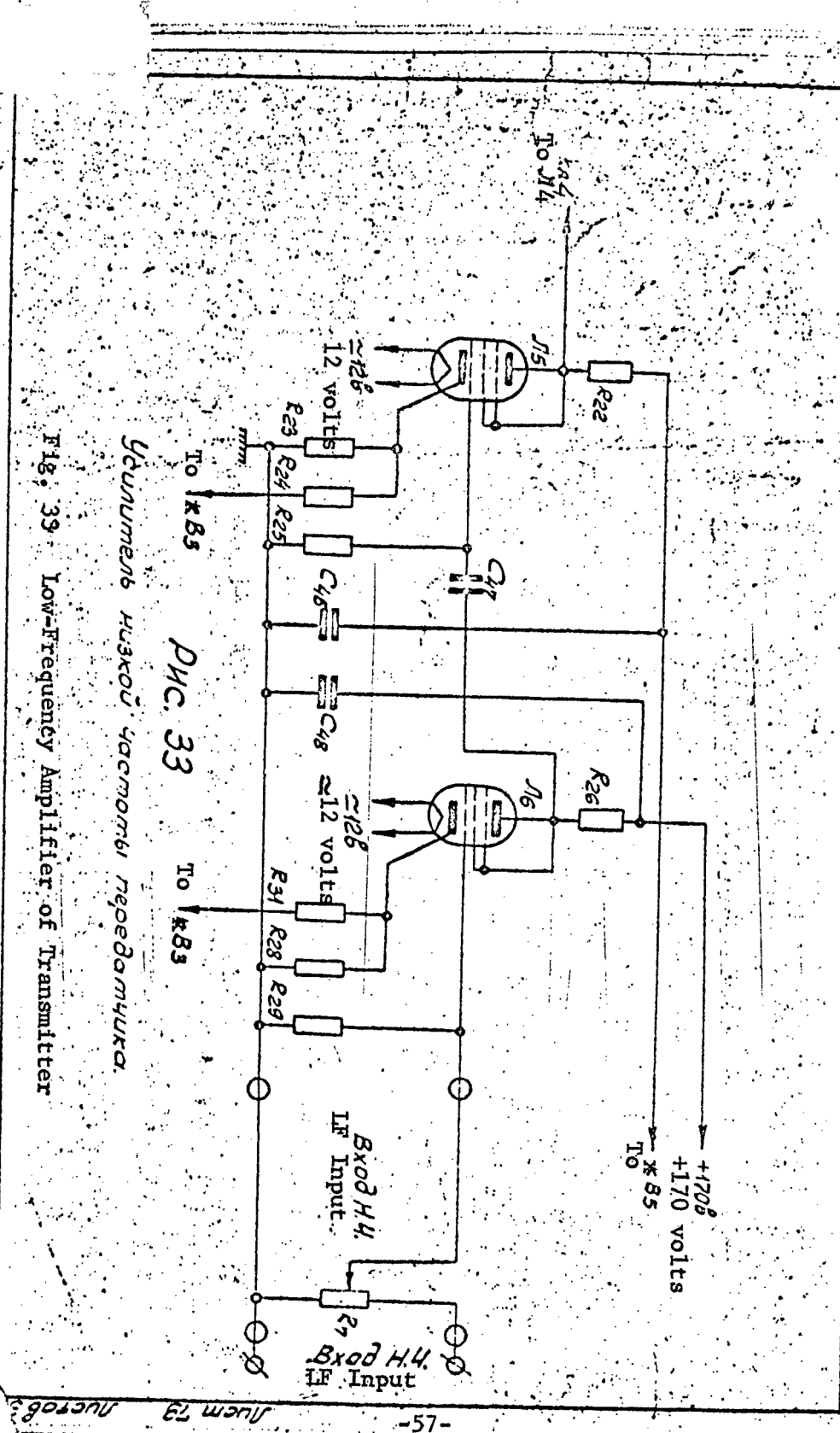
Proper operating condition of the frequency modulator tube is indicated according to the value of the d-c component of the cathode current which, having passed through resistor R20, places a potential on it. This potential is fed to the same indicator device through resistor R21 by means of switch B3.

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Modulation Amplifier

The modulation amplifier is a two-stage low-frequency amplifier used to raise the signals incoming from the telephone and telegraph sections to a value necessary for the normal operation of the frequency modulator of the transmitter. The modulation amplifier gain factor in a frequency band extending from 300 to 16,000 cycles is not less than 200.

Each stage of the modulation amplifier is set up in a rheostat circuit using type 12Zh1L tubes (Fig. 38), operating in the triode mode, which makes it possible to achieve low nonlinear distortion in the amplifier. The plate load of tube Л5 is resistor R22 and the plate load of tube Л6 is resistor R26 (Fig. 33).

Potentiometer R7, located on the front panel of the section (Fig. 23, No. 12), is connected to the input of the modulation amplifier (Л6) through contacts 3-2 of adapter block Л3. By means of this potentiometer, the value of the modulating voltage fed to the amplifier is controlled and in this way the required frequency deviation of the master oscillator is set.

The amplifier stages are coupled by means of capacitor C47, while the output stage is coupled with the frequency modulator by means of capacitor C44.

The plate voltage is fed to the second stage of the modulation amplifier (Л5) through switch B5 КАЛИБР-ВЫКЛ. ("CALIBRATOR-OFF"), located on the front panel of the section (Fig. 23, No. 10). When the crystal calibrator is connected, the plate voltage circuit of tube Л5 is broken.

The bias is automatically fed to the control grids of the modulation amplifier tubes through the voltage drop in resistors R23 and R28 which are connected to the cathode circuit of each tube. These resistors are not capacitor-shunted, which gives rise to negative current feedback in each stage and provides for reduced nonlinear distortion in the amplifier. Proper operating condition of the tubes making up the modulation amplifier is checked in the same manner as in the remaining stages of the transmitter.

Radio Receiving Unit

A radio receiving unit of the superheterodyne type with double-frequency conversion, automatic frequency control (AFC) and automatic gain control (AGC) is employed for the reception of the high-frequency FM signals incoming from the antenna.

The radio receiving unit is mounted in two separate cast Silumin frames which represent the high-frequency amplifier (УВЧ) element and the intermediate-frequency amplifier (УНЧ) element. The УВЧ (HF Amp.) and УНЧ (IF Amp.) elements are divided into a number of compartments in which are installed the individual components and sub-assemblies of the receiving unit circuitry (Fig. 26, Nos. 2 and 3). The design of the УВЧ (HF Amp.) element is analogous to that of the transmitter element. Access is provided to all circuit components of the radio receiving unit without the need to remove the УВЧ and УНЧ elements from the section mounting rack.

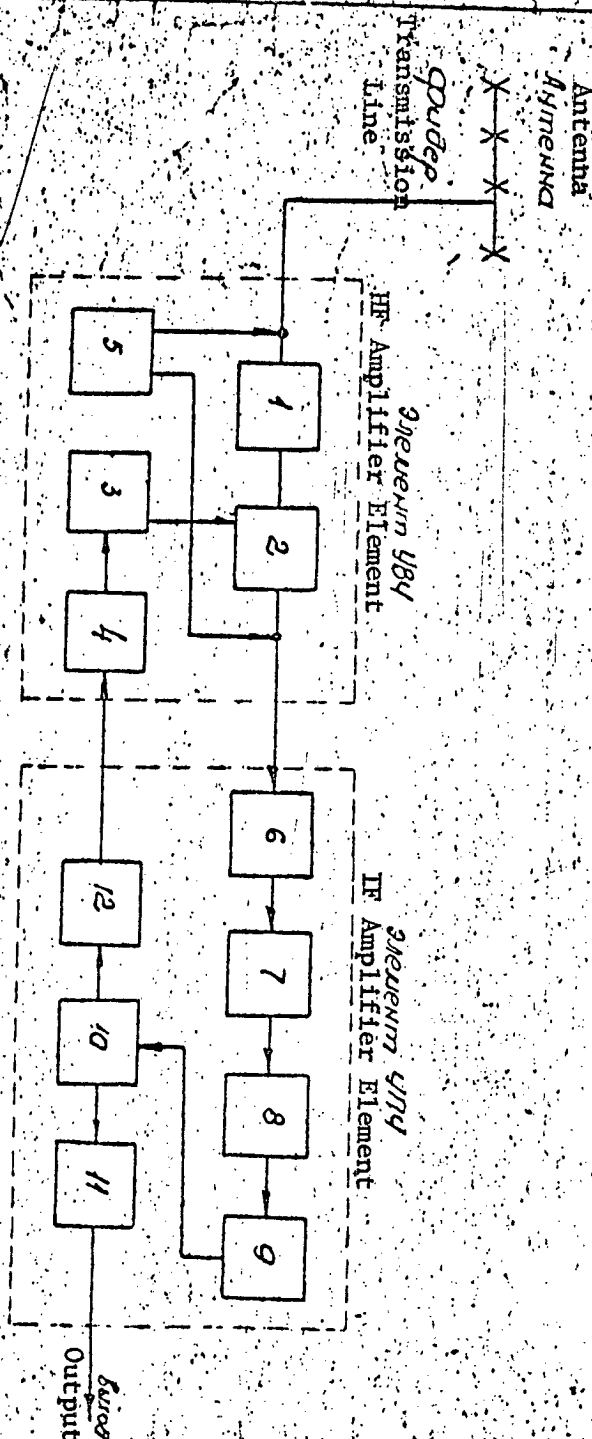
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Рис. 34. Блок-схема радиоприемного устройства

Fig. 34. Block Diagram of Radio Receiving Unit

Рис. 34



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A block diagram of the radio receiving unit is given in Fig. 34. Installed in the $\mathcal{Y}\mathcal{B}\mathcal{Y}$ (HF Amp.) element (Fig. 34) are the following: high-frequency amplifier 1, mixer 2, heterodyne 3, frequency control unit 4, and crystal calibrator 5. The tuning system for all the high-frequency circuits of the $\mathcal{Y}\mathcal{B}\mathcal{Y}$ (HF amp.) element uses a single control and is similar in every design aspect to the tuning system of the high-frequency circuits of the transmitter.

Mounted in the $\mathcal{Y}\mathcal{N}\mathcal{Y}$ (IF Amp.) element are: first intermediate-frequency amplifier 6, frequency converter 7, second intermediate-frequency amplifier 8, amplitude limiter 9, frequency detector 10, low-frequency amplifier 11, direct voltage amplifier 12 for the AFC system, and AGC system (diode $\Delta 3$ is used as a detector).

Proper operating condition of all the tubes of the radio receiving unit is checked by means of switches B2 and B3 and indicator device $\mathcal{M}\mathcal{N}$, located on the front panel of the transceiver (Fig. 23, No. 6).

All the electric power supply circuits for the radio receiving unit pass through noise-suppression filters consisting of inductances L15-19 and duct capacitors C54-58. The noise-suppression filters are located in the $\mathcal{Y}\mathcal{B}\mathcal{Y}$ (HF Amp.) element.

High-Frequency Amplifier

The high-frequency amplifier (Fig. 35) is a two-stage resonance amplifier with parallel feed using tubes type 12Zh1L ($\mathcal{M}1$ and $\mathcal{M}2$). It provides the required amplification of the received signal before the mixer and also the necessary suppression of image channel interference in the first intermediate frequency (Fig. 35).

Input circuit L1-C1 is coupled with the antenna directly through a tap on the autotransformer while coupling with the control grid of the first tube ($\mathcal{M}1$) of the amplifier is across the entire coil.

Circuits L3-C11 and L5-C20 are loosely coupled with the tube. This is achieved by means of capacitance dividers formed by capacitors C8, C9, C17, C18 and the corresponding input and output capacitances of tubes $\mathcal{M}1$, $\mathcal{M}2$ and $\mathcal{M}3$.

Circuit coils L1, L3 and L5 and cylindrical variable capacitors C1, C11 and C20 are designed similarly to the transmitter circuits (Fig. 28).

Bias is automatically fed to the control grids of the amplifier tubes through the voltage drop in resistor R1 through which flows the cathode current of both tubes of the amplifier (the cathodes of tubes $\mathcal{M}1$ and $\mathcal{M}2$ are interconnected).

Proper operating condition of the amplifier tubes is checked by means of indicator device $\mathcal{M}\mathcal{N}$ connected to the cathode resistor R1 through resistor R6. The leak resistance of tube $\mathcal{M}2$ consists of two resistors R4 and R5. When switch B2 is set in position AHT ("ANTENNA"), indicator device $\mathcal{M}\mathcal{N}$, which is located on the front panel of the section, is connected to resistor R5. In this case, when the transmitter is tuned to the frequency of the receiver (or the receiver to the frequency of the transmitter), with the antennas connected, the grid current of tube

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μ 2 is suppressed because of the rather strong signal from the transmitter. The voltage fall on resistor R5, caused by the grid current of the tube, will be measured by the indicator device. The readings of the indicator provide a basis for verifying the proper operating condition of the antenna-feeder systems of the transceiver.

Capacitors C3, C4, C5, C6, C7, C12, C13, C14, C15, C16 and C59 are blocking capacitors.

Mixer

The mixer is a 12Zh1L tube (μ 3) with a double-grid frequency conversion circuit (Fig. 36). The received high-frequency oscillations (60-70 Mc) are converted in the mixer into oscillations of the first intermediate frequency of 6.6 Mc (Fig. 36).

The signal voltage taken from plate circuit L5-C20 of the second high-frequency amplifier stage is fed through isolating capacitor C18 to the control grid of mixer tube μ 3. The voltage taken from the plate circuit (L13-C45) of the heterodyne is fed to the suppressor grid of mixer tube μ 3. The suppressor grid, in this case, functions as a second control grid.

In order to separate the intermediate frequency signal in the plate circuit of mixer tube μ 3, there is connected a band filter consisting two circuits, L6-C25 and L7-C27, interconnected by external capacitance C28. Both of these circuits are shielded one against the other; at the same time, the shields serve to hermetically seal the circuit. The coils of these circuits are designed on closed carbonyl type SV-3a cores. The first intermediate frequency voltage, taken from the second circuit L7-C27, is fed by means of a type RK-19 high-frequency cable from the μ 84 (HF Amp.) element to the μ 04 (IF Amp.) element to the control grid of tube μ 7 of the first intermediate frequency amplifier (Fig. 38).

The bias voltage is automatically fed to the suppressor grid of the tube through resistor R10 by virtue of the voltage drop in resistors R12 and R16 which are connected to the cathode circuit of tube μ 3. The bias voltage is fed to the control grid of this tube through resistor R11 through the voltage drop in resistor R12 alone.

Proper working condition of the mixer tube is checked by means of indicator device μ 1 which is connected to the cathode of the tube by means of switch B3 through resistor R9.

Capacitors C21, C22, C23, C24 and C26 are blocking capacitors.

Heterodyne

The receiver heterodyne uses a type 12Zh1L tube (μ 5), and is designed in a two-circuit arrangement with electron coupling (Fig. 37). The circuit, design and operational principle of the receiver heterodyne are analogous to the master oscillator of the transmitter (see above). The sole difference consists in the fact that the receiver heterodyne operates in a frequency band of 53.4-63.375 Mc (Fig. 37). Plate circuit L13-C45 of the heterodyne is coupled with tube μ 5, for design considerations, by means of two capacitors C42 and C46. The voltage to

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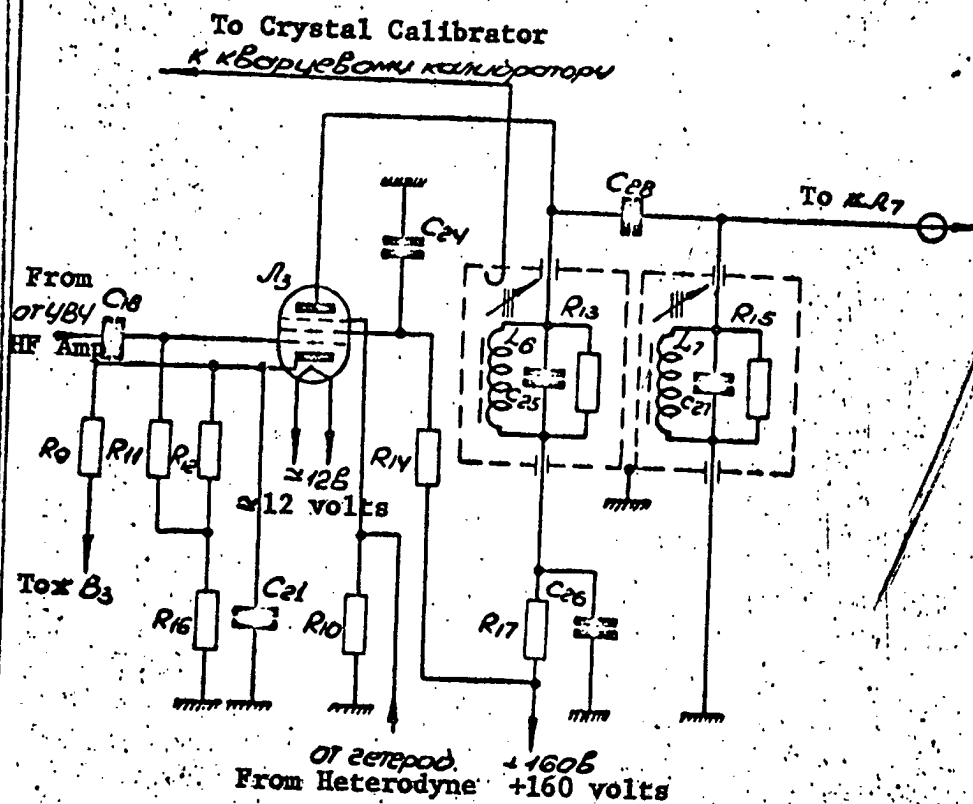


Рис. 36 Система смесителя.

Fig. 36 Mixer Diagram

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the suppressor grid of mixer tube $\mathcal{N}3$ is taken from the plate circuit of the heterodyne through capacitor C46. Proper operating condition of the heterodyne tube is checked by connecting indicator device $\mathcal{N}\mathcal{N}$ to resistor R27, connected to the cathode circuit of the tube, by means of switch B3 through resistor R23.

The purpose of the remaining components of the receiver heterodyne is similar to that of the corresponding components of the master oscillator of the transmitter.

First Intermediate-Frequency Amplifier

The amplifier of the first intermediate-frequency is a single-stage amplifier using a type 12Zh1L tube ($\mathcal{N}7$). The first intermediate frequency voltage, taken from the plate circuit of mixer tube $\mathcal{N}3$ (Fig. 36) is fed to the control grid of tube $\mathcal{N}7$ through isolating capacitor C60 (Fig. 38). Connected to the plate circuit of this tube as a load, is a band filter consisting of two circuits L21-C63 and L22-C65, interconnected by external capacitance C64. The filters are tuned to the first intermediate frequency of 6.6 Mc and designed similarly to the circuits of the anode band filter of the mixer (see above) (Fig. 38).

The bias is automatically fed to the control grid of tube $\mathcal{N}7$ through the voltage drop in resistor R36 connected to the cathode circuit of the tube.

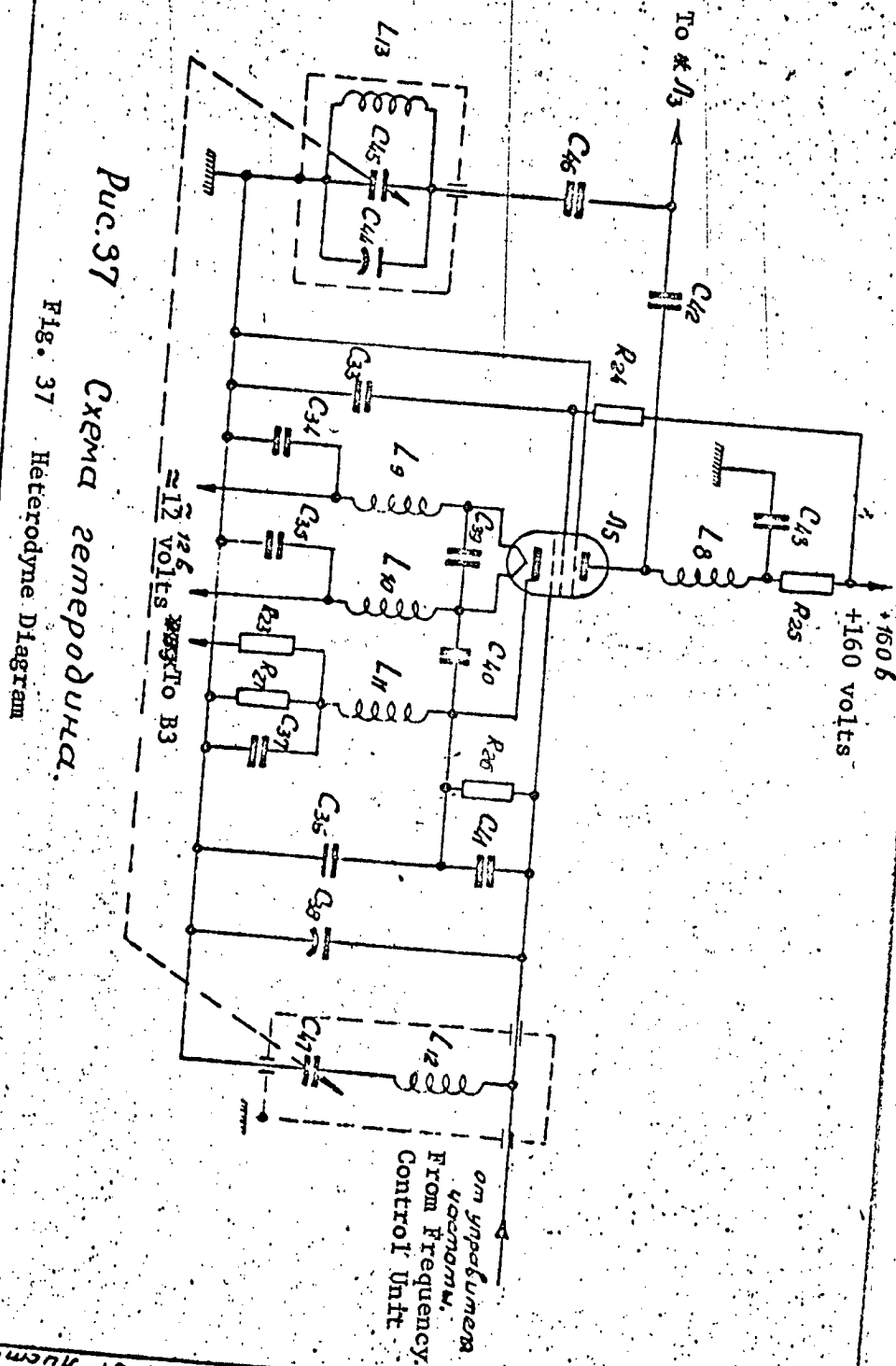
Proper operating condition of tube $\mathcal{N}7$ is checked by connecting indicator device $\mathcal{N}\mathcal{N}$ to cathode resistor R36 by means of switch B3 through resistor R35.

C61, C62 and C116 are blocking capacitors.

Frequency Converter

The frequency converter uses a type 12Zh1L tube. Tube $\mathcal{N}8$ of the frequency converter simultaneously performs the functions of the second frequency mixer and the second crystal-stabilized heterodyne KB-2 (Fig. 39). The crystal is connected between the control and screen grids. The screen grid is used as the heterodyne plate. The crystal frequency is 7.06 Mc. As a result of the effect on the converter tube ($\mathcal{N}8$) control grid of the oscillations of the first 6.6-Mc intermediate frequency, taken from the anode band filter of the first intermediate-frequency amplifier ($\mathcal{N}7$) through separating capacitor C66, and the natural oscillations of 7.06 Mc, there are generated in the plate circuit of tube $\mathcal{N}8$ oscillations with a 460-kc difference frequency which is used as the second intermediate frequency. The oscillations of the second intermediate frequency are discriminated in the plate circuit of tube $\mathcal{N}8$ by means of an 11-circuit filter of concentrated selection with a characteristic impedance of 15 kilohms. The load resistance of filter R47 and the plate load resistance R41 of tube $\mathcal{N}8$ equal the characteristic impedance of the filter. The passband and adjacent channel selectivity of the receiver are basically determined by the concentrated selection filter. The width of the receiver passband with an attenuation factor of 2 is not narrower than 46 kc, and with an attenuation factor of 1000, not wider than 100 kc.

Design-wise, the concentrated selection filter consists of an independent hermetically sealed assembly. All filter circuits are shielded against one another. The coils of the end filter circuits L23 and L33 are designed on closed carbonyl cores type SB-1a, while the cores of the remaining circuits use closed carbonyl cores type SB-3a.



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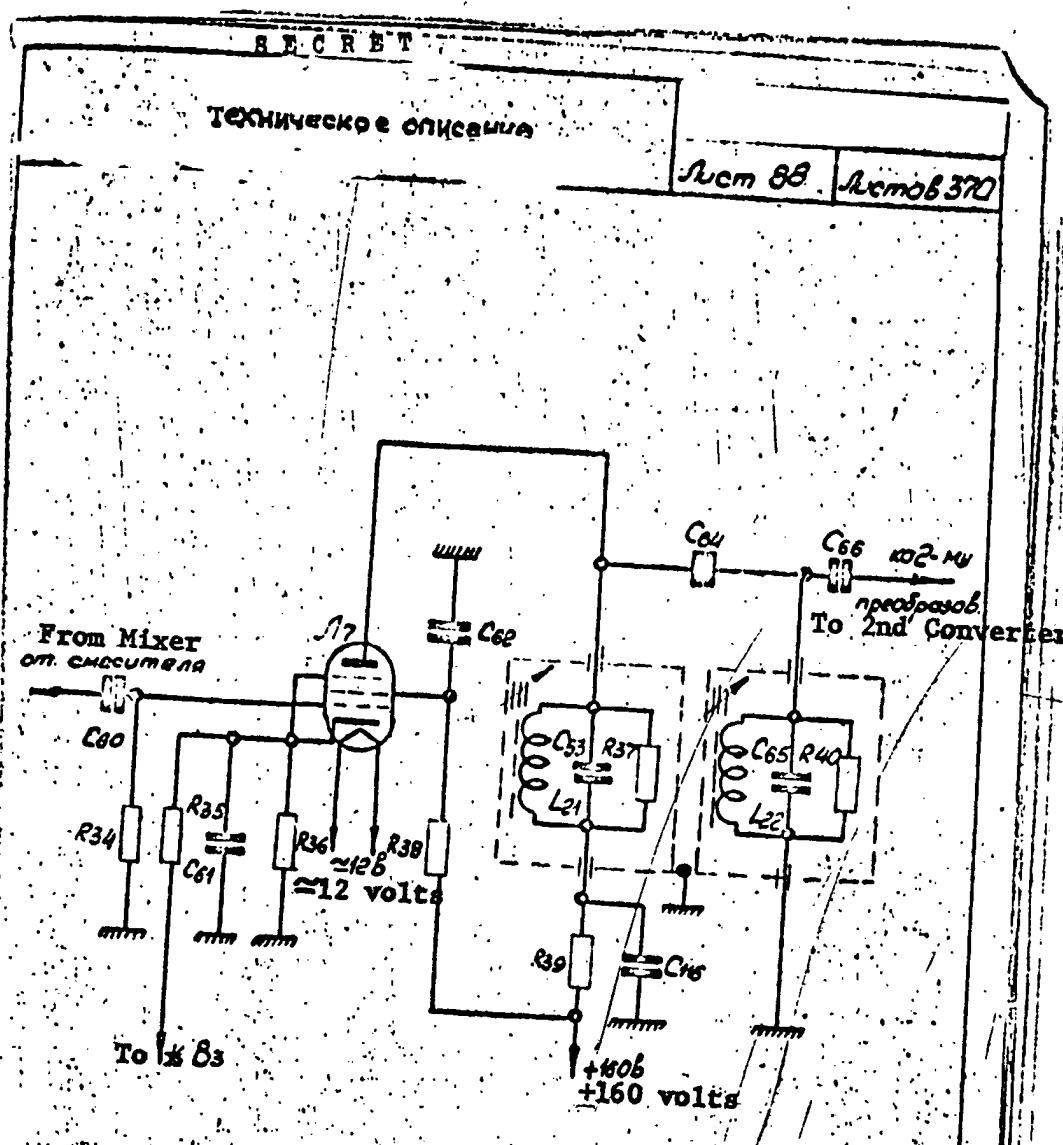


Рис. 38

Схема усилителя первой промежуточной частоты.

Fig. 38 Diagram of First Intermediate Frequency Amplifier

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C69 and C83 are isolating capacitors.

The bias is fed automatically to the control grid of converter tube J18 by the passage of the heterodyne grid current through resistor R44. Proper operating condition of tube J18 is checked by connecting indicator device M1 to small cathode resistor R45 by means of switch B3 through resistor R46.

Capacitors C67 and C68 are blocking capacitors.

Second Intermediate-Frequency Amplifier

The amplifier of the second intermediate frequency is a three-stage amplifier using type 12Zh1L tubes. The first and third stages of the amplifier (J19 and J11) have as a plate load single oscillatory circuits L34-C86 and L37-C97 (Fig. 40). The second stage of the amplifier (J10) has as a plate load a band filter consisting of two circuits L35-C91 and L36-C93, coupled by external capacitor C92 (Fig. 40). The circuit coils of the second intermediate-frequency amplifier are designed to use closed carbonyl cores types SB-1a and SB-3a and are enclosed in independent shields which serve at the same time to hermetically seal them.

For expansion of the passband all circuits of the second intermediate-frequency amplifier are shunted by resistors R52, R58, R59 and R64.

C87, C94 and C98 are isolating capacitors.

Proper operating condition of tubes J19 , J10 and J11 is checked by connecting indicator device M1 to the corresponding small cathode resistors R50, R56 or R61 by means of switch B3 through resistors R49, R55 or R62.

The purpose of the remaining circuit elements of the second intermediate-frequency amplifier is similar to that of the corresponding elements of the other stages of the radio receiving unit.

Amplitude Limiter

The amplitude limiter employs a type 12Zh1L tube (J12) and operates in the grid detection mode with low voltage on the plate and screen grid of the tube (about 60 volts). As the voltage of the second intermediate frequency, fed to the control grid of limiter tube 12 through isolating capacitor C98 (Fig. 41), increases, the negative bias on the control grid of this tube rises. This bias potential is generated on resistor R66 by the grid current of tube J12 (Fig. 41).

As the negative bias increases on the control grid of the limiter tube, the mean transconductance of the plate current characteristic of the tube and, consequently, the gain of this stage as well, falls off. Under very high second intermediate-frequency voltage, when the negative bias on the control grid of the limiter tube increases considerably (to 30 volts), tube J12 begins to operate with plate current cut-off. This leads to a reduction in the d-c component of the plate current of the tube, which causes an increase in voltage on the plate and screen grid, since the voltage drop in resistors R79 and R80 is lessened. Because of this, the mean transconductance of the plate current characteristic and the gain factor of the limiter stage remain constant for all values of the second intermediate-frequency voltage which exceed the so-called limiting

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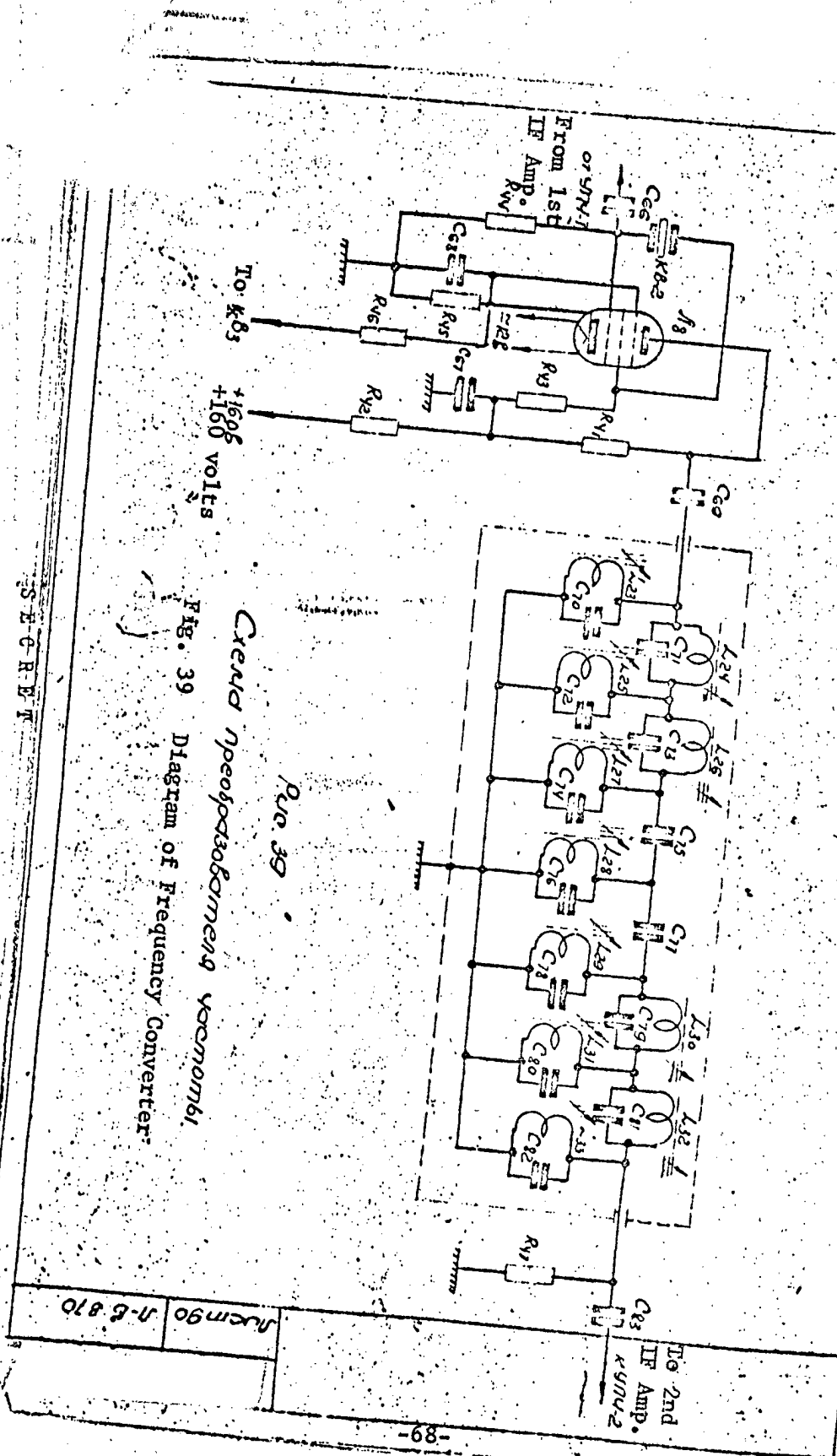
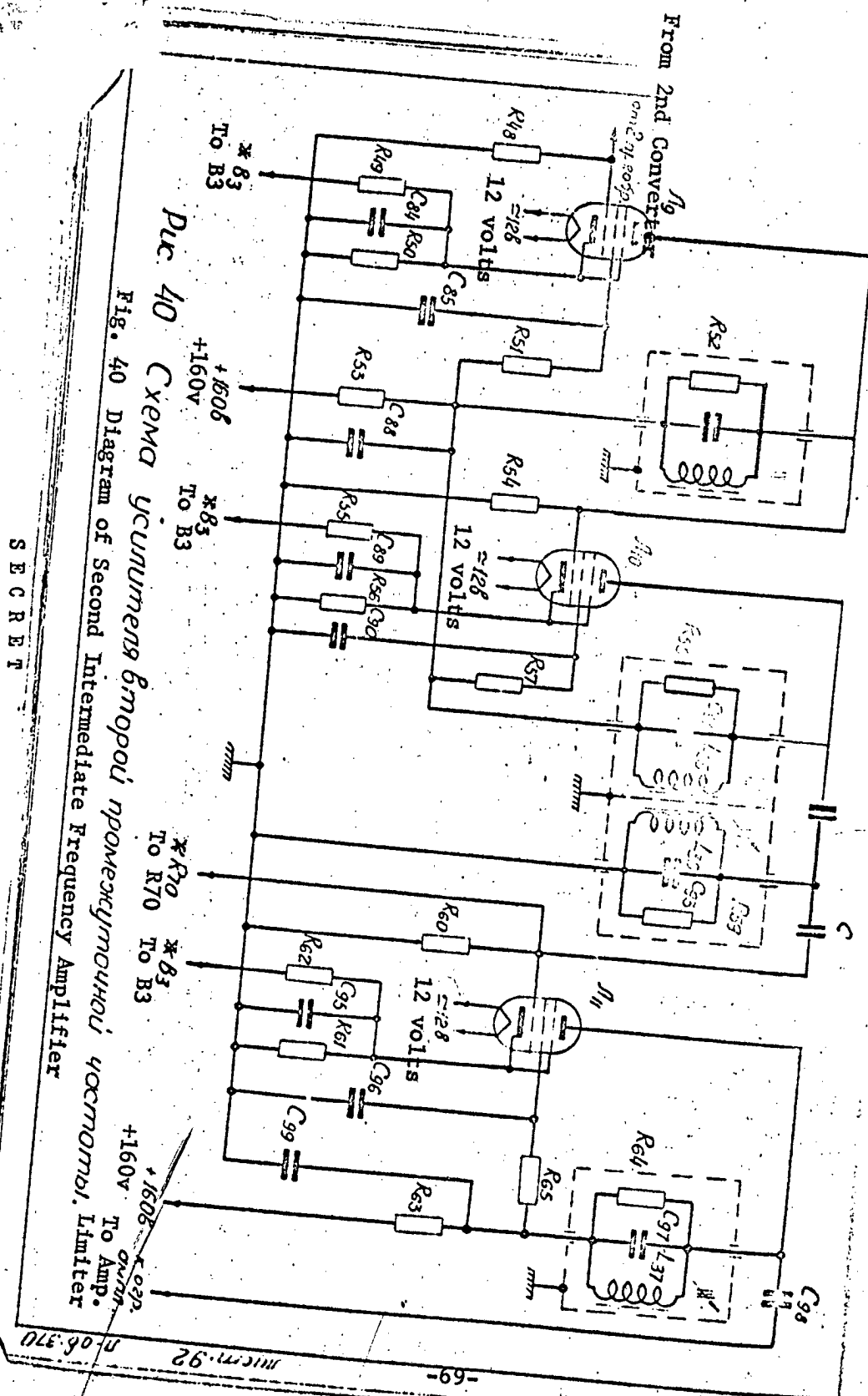


Fig. 39 Diagram of Frequency Converter.

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threshold (Fig. 42). In addition, if the levels of the high-frequency signal at the receiver input are very high, tubes $\mathcal{N}11$, $\mathcal{N}10$ and $\mathcal{N}9$ of the second intermediate-frequency amplifier and tube $\mathcal{N}7$ of the first intermediate-frequency amplifier also begin, in similar fashion, to operate with grid limitation of the amplitude of the received signal. An additional factor leading to this mode of operation is the automatic gain control (AGC) of the final stage of the intermediate-frequency amplifier (11), brought about through germanium diode 3 connected to the grid circuit of limiter tube $\mathcal{N}12$. The voltage rectified by this diode and taken from resistor R67 is fed over resistor R70 to the control grid of tube $\mathcal{N}11$ as additional negative bias. Consequently, even a very sharp rise in the intermediate-frequency voltage beyond the limiting threshold (an increase in the voltage of the received signal) does not result in increased voltage on the plate circuit of the amplitude limiter. In addition, the AGC feature provides better conditions for the operation of the AFC system of the receiver with weak signals.

Proper operating condition of the amplitude limiter tube, as also in the other stages of the receiving unit, is checked by connecting indicator device $\mathcal{N}1$ to small cathode resistor R69 by means of switch B3 through resistor R68.

C100, C101 and C111 are blocking capacitors.

Frequency Detector

The frequency detector is used to convert the frequency-modulated oscillations of the second intermediate frequency into low-frequency oscillations. For this purpose, there is connected to the plate circuit of limiter tube $\mathcal{N}12$ (Fig. 41) an oscillatory circuit consisting of two series-connected inductances L38 and L40 and capacitors C102 and C103. This circuit is tuned to the second 460-kc intermediate frequency and shunted by resistor R71 in order to expand the pass-band. Inductively coupled to this circuit are two other circuits: circuit L39-C106 tuned to 490 kc and circuit L41-C107 tuned to 430 kc. If the second intermediate frequency is precisely equal to 460 kc, there arise in oscillatory circuits L39-C106 and L41-C107 identical intermediate-frequency voltages which pass through capacitors C108 and C109 to the diodes of tube 15 (double diode 6 X 2P) for rectification. The currents rectified by the diodes give rise in resistors R72 and R73 to d-c voltages, equal in amplitude but of opposite polarity. The resultant voltage in the load resistors (between the upper point of resistor R72 and ground) will equal zero.

If the second intermediate frequency changes in either direction, the voltages in circuits L39-C106 and L41-C107 will no longer be identical. With an increase of frequency ($460 + \Delta f$), the voltage in the upper circuit L39-C106 will be greater than that in the lower circuit.

As a result, the current rectified by the upper diode of tube $\mathcal{N}16$, and, consequently, the voltage in resistor R72 also, will be greater than the current rectified by the lower diode of tube 15 and the voltage in resistor R73. Thus, with an increase in frequency, the upper point of resistor R72 will have negative potential with respect to ground. With a decrease in frequency ($460 - \Delta f$), the rectified voltage of the lower diode of tube $\mathcal{N}15$ will predominate and the upper point of resistor R72 will have positive potential with respect to ground. The greater the detuning Δf or its deviation Δf_n , the greater will be the value of the voltage between the upper point of resistor R72 and ground.

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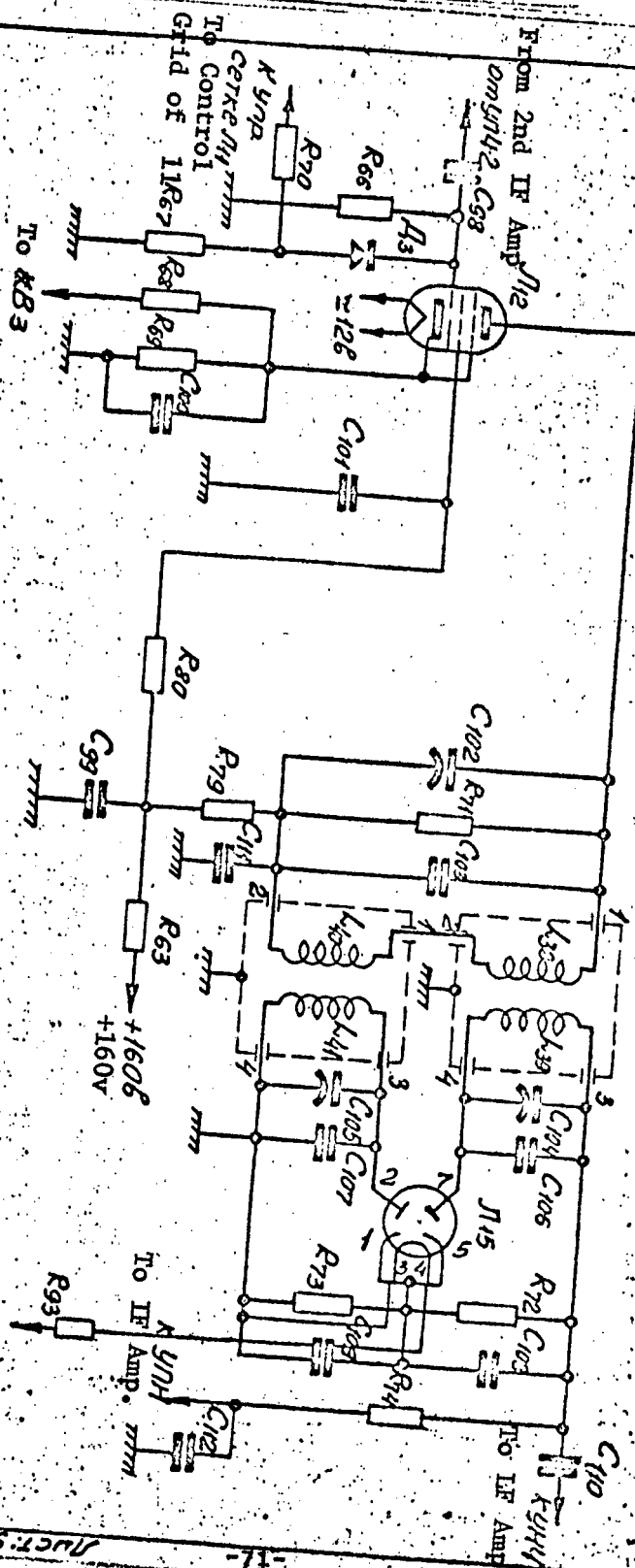


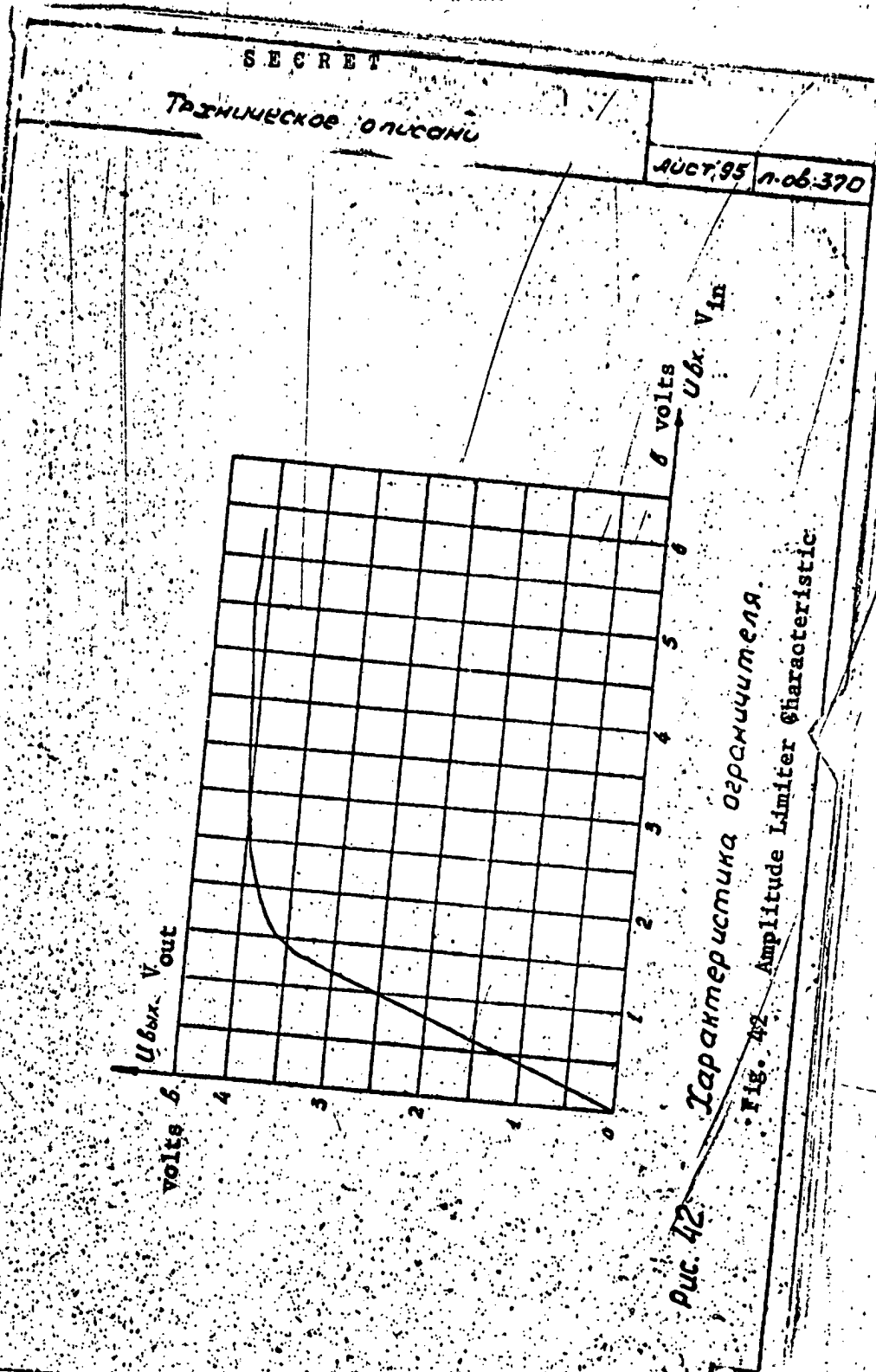
Рис. 41 Схема ограничителя амплитуды и частотного детектора.
Fig. 41 Diagram of Amplitude Limiter and Frequency Detector.

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In the case of prolonged operation of the section, its temperature rises to $+70^{\circ}\text{C}$, leading to detuning of the discriminator circuits. The tuning frequency of the discriminator circuits drops as it changes; that is, the positive potential with respect to ground increases and, consequently, the discriminator zero does not correspond to the 460-kc frequency.

Capacitors C106 and C107 of groups M and C with negative temperature coefficient are introduced for thermal stabilization of the discriminator circuits.

Fig. 43 shows the static characteristic of the frequency detector, representing the output voltage V_{out} (the voltage between the upper point of resistor R72 and ground) as a function of frequency detuning Δf in comparison with the mean value of the frequency (460 kc).

When an amplitude-modulated signal is received, there appears at the output of the frequency detector a low-frequency signal which changes in accordance with the modulation of the high-frequency signal; that is, the radio-transmitted signal is received at the output of the frequency detector.

From the frequency detector output the low-frequency voltage is fed through isolating capacitor C110 to the input of the low-frequency amplifier. Taken from the same point (the upper point of resistor R72) is the direct voltage for the operation of the AFC system.

Low-Frequency Amplifier

The low-frequency amplifier consists of a type 12Zh1L tube ($\mathcal{N}13$) in a transformer circuit (Fig. 44). The low-frequency voltage is fed from the frequency detector load (upper point of resistor R72) through isolating capacitor C110 and voltage divider R75-R76 to the control grid of tube $\mathcal{N}13$. Potentiometer R75 is used to set the output level of the receiver.

Step-down transformer Tpl is connected to the plate circuit of the low-frequency amplifier tube. From the secondary winding 3-4 the low-frequency signals are fed to the multiplexing device (telephone and telegraph sections), while secondary winding 5-6 constitutes the output to external multiplexing equipment. The low-frequency amplifier tube operates in the triode mode (the screen and suppressor grids are connected with the plate), thus providing low nonlinear distortion in the amplifier.

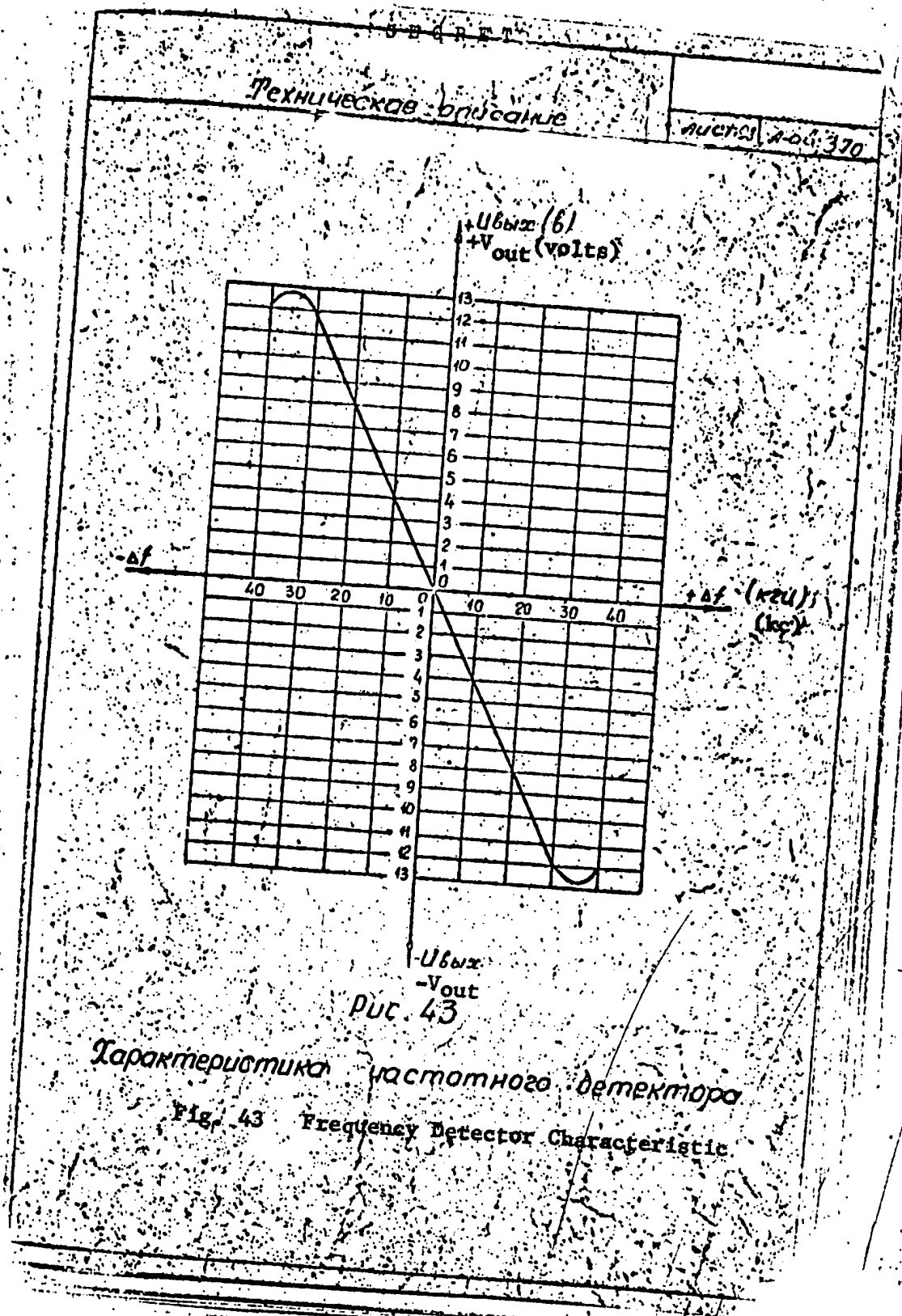
In order to reduce the steep slope of the frequency response curve at 300 cycles, negative voltage feedback is fed from the plate of the tube to the control grid through capacitor C113 and resistor R77. For the same purpose (namely, that of reducing the steep slope of the frequency response curve) on the 16,000-cycle frequency, capacitor C117 is connected in parallel with the primary winding of output transformer Tpl.

The bias voltage is automatically fed to the control grid of tube $\mathcal{N}13$ through the voltage drop in resistor R78 connected to the cathode circuit of the tube.

Proper operating condition of the low-frequency amplifier tube is determined by the presence at its output of a signal voltage or receiver noise voltage (in the absence of a signal from a corresponding station).

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Automatic Frequency Control

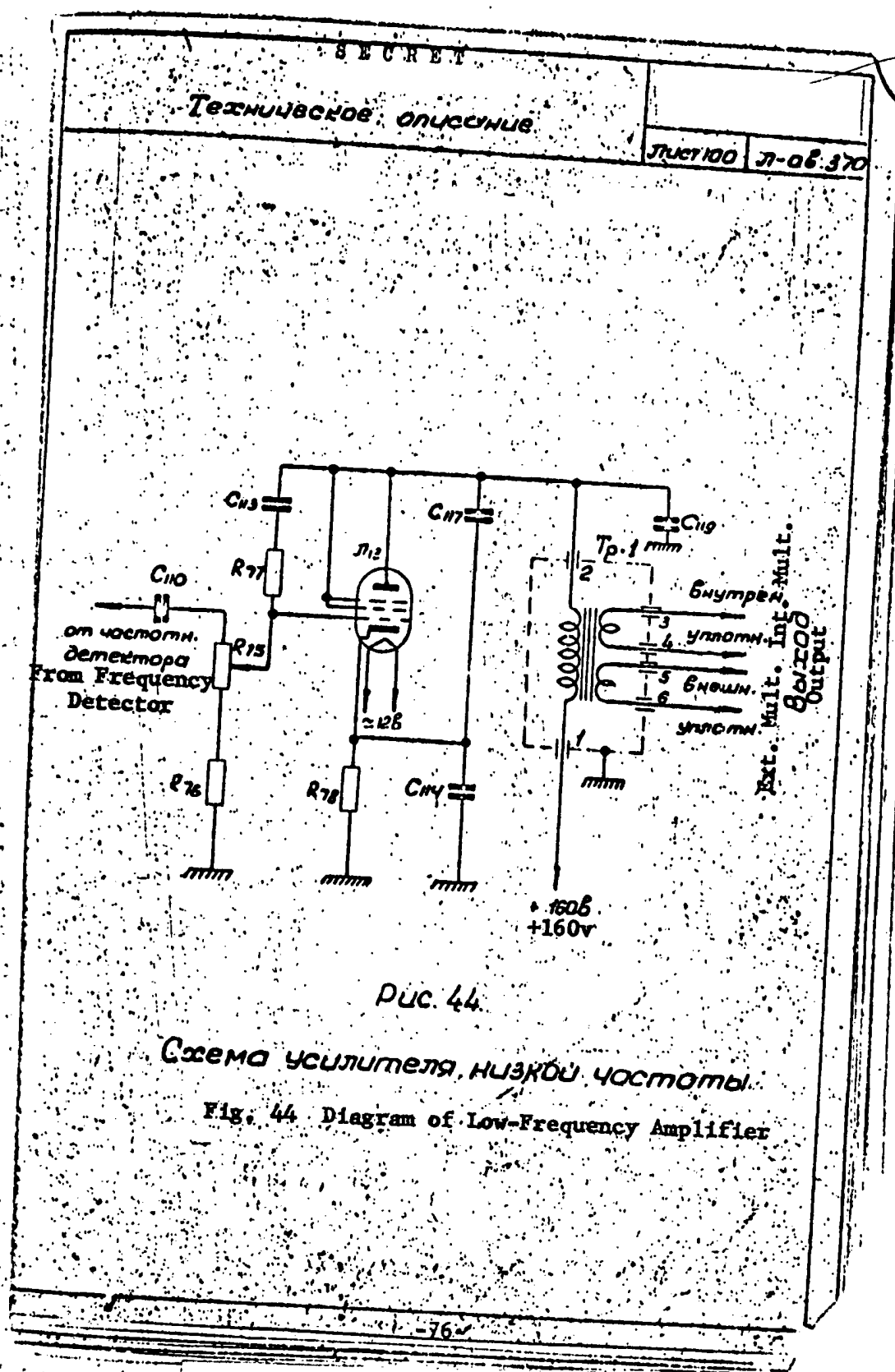
Automatic frequency control (AFC) is designed to reduce the detuning of the receiver frequency with respect to the frequency sent out by the transmitter, for the purpose of providing satisfactory communication without the need of retuning. In addition, accurate tuning of the receiver to the frequency of the transmitter is necessary in multichannel communication in order to reduce crosstalk between channels.

The automatic frequency control system feature operates in the following fashion. The regulating voltage, which appears when the receiver is detuned, is fed from the load of the frequency detector R72-R73 (Fig. 41) through the filter consisting of resistor R74 and capacitor C112 to the control grid of tube J14 of the direct voltage amplifier. The time constant of this filter is so selected that the AFC system will not react to short-term frequency detuning which is the result of the frequency modulation of the transmitter carrier. Consequently, the AFC can operate upon reception of an FM signal, with the amplitude and polarity of the regulating voltage depending on the amplitude and polarity of the deviation of the second intermediate frequency from the mean tuning frequency (460 kc) of the frequency detector (Fig. 43).

The d-c voltage amplifier (Fig. 45), a 12Zh1L tube (J14), is used to increase the AFC regulation factor. The first and third grid of the tube are employed as control grids in order to increase the gain of the d-c voltage amplifier. In order that the AFC system not react to low-frequency signals, in addition to filter R74-C113 which has a large time constant and is connected to the amplifier input, the plate of tube J14 is blocked by large capacitor C115. The amplified direct voltage is fed from the plate of tube J14 through resistor R83, switch B7 (the AFC toggle switch) and resistor R29 to the control grid of the frequency control unit J6 (Fig. 46). In order to compensate for the positive voltage reaching the control grid of frequency control tube J6 from the plate of the d-c voltage amplifier tube J14 (Fig. 45), a 60-volt compensating voltage is fed from a special current source to resistor R83. The compensation point of this positive voltage is effected by potentiometer R88 connected to the +60 volt circuit. The potentiometer control is found under the slot on the left side panel of the transceiver section (Fig. 26, No. 18).

The frequency control unit employs a type 12Zh1L tube (J6) operating as a triode (Fig. 46). The basic diagram and operational principle of the frequency control unit are similar to those of the transmitter frequency modulator (see above), the sole difference consisting in the fact that in place of choke L13 (Fig. 32) in the frequency control unit of the receiver, there is resistor R29 (Fig. 47); the inductance of this choke, together with the wiring capacitance forms an oscillatory circuit tuned to the lower frequency of the band. The control grid of the frequency control tube is connected with the grid circuit L12-C47 of the receiver heterodyne through isolating capacitor C53. The control voltage fed to the grid of frequency control tube J6 from the frequency detector leads to a reduction in the initial detuning of the receiver frequency with respect to the transmitter frequency.

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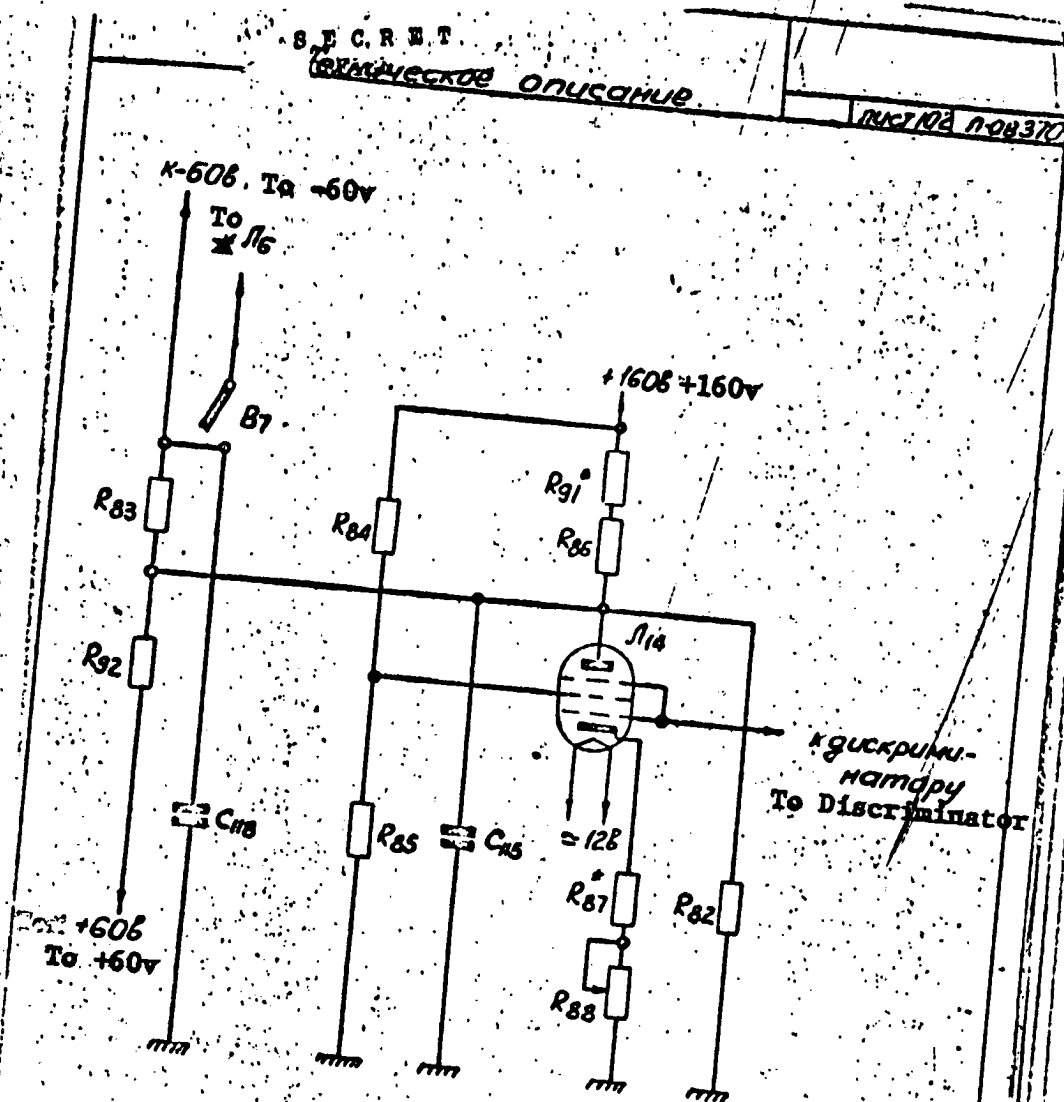


Рис. 45

Схема усилителя постоянного напряжения.

Fig. 45 Diagram of D-C Voltage Amplifier

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In the R-401M, AFC operates within the limits of ± 25 kc. Residual detuning as a result of the effect of the AFC system does not exceed 3 kc. Proper operating condition of frequency control tube J6 and the proper operation of the AFC system is checked by indicator device ИП which is connected to cathode resistor R33 by means of switch B3 through resistor R32.

The purpose of the remaining components of the frequency control unit (6) is the same as that of analogous components of the transmitter frequency modulator (see above).

Crystal Calibrator

The crystal calibrator of the station, located in the J87 (HF Amp.) element of the receiver, is designed to correct the frequency of the receiver and transmitter when replacing tubes of the master oscillator and frequency modulator of the transmitter and first heterodyne and frequency control unit of the receiver, as well as to check the frequency calibration accuracy of the transmitter and receiver (Fig. 47).

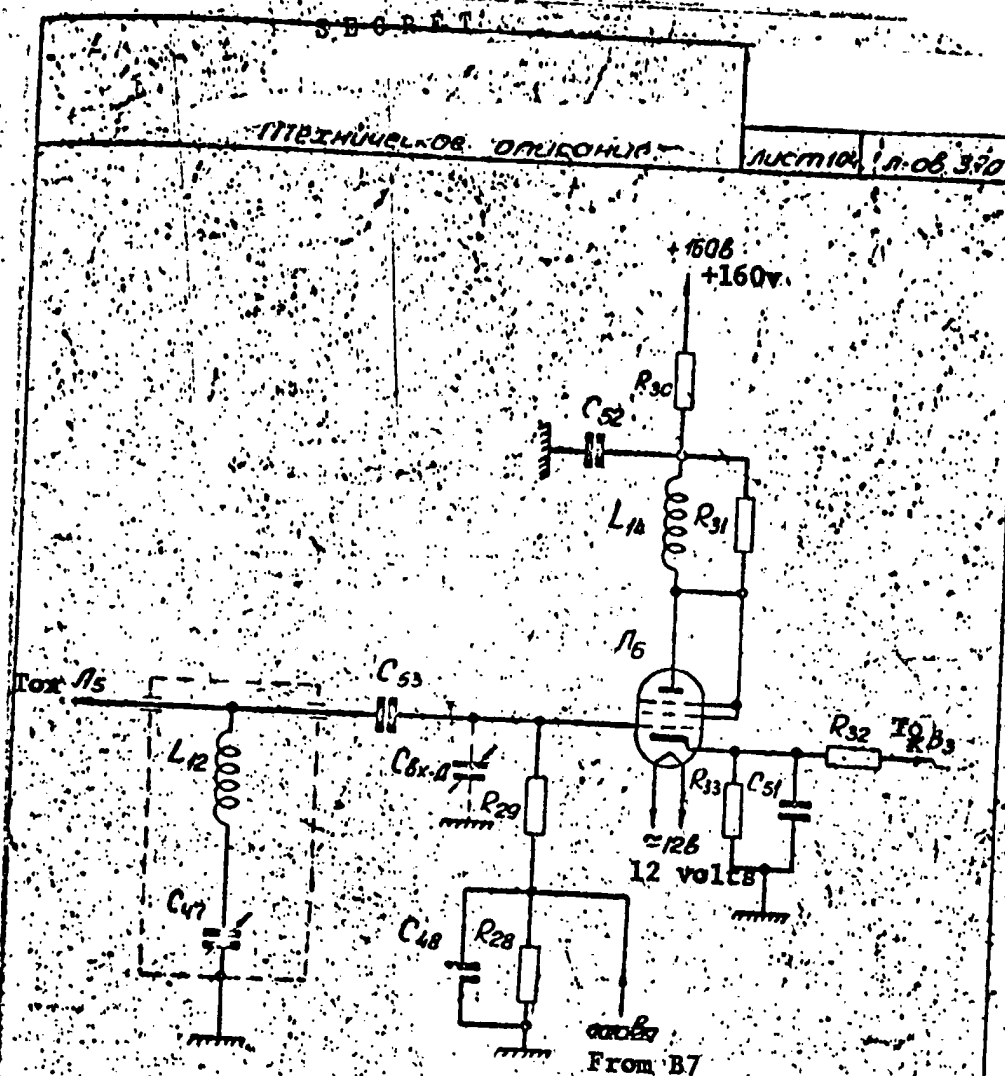
The crystal calibrator uses a type 12Zh1L tube (J4) operating as a triode (Fig. 47). The quartz crystal K-81 is connected between the plate and control grid of tube J4 through isolating capacitor C31. Crystal frequency is selected as one-half the first intermediate frequency of the receiver ($f_{\text{cr.}} = 3.3$ Mc). Bias on the control grid of tube J4 is formed automatically because of the voltage drop in resistor R22 as the grid current of the tube passes through it. Resistor R20 constitutes the load in the plate circuit of tube J4 . The crystal calibrator is switched on by means of switch B5 located in the filament circuit of tube J4 of the crystal calibrator. Design-wise, this switch is located on the front panel of the transceiver section (Fig. 23, No. 10). When oscillations arise in the crystal calibrator, there is created in load resistor R20 a voltage of the crystal frequency $f_{\text{cr.}}$ and its harmonics $nf_{\text{cr.}}$, where n is the number of the crystal harmonic (an integer). The voltage from the plate load R20 is fed through capacitor C30 to the receiver input and to the plate circuit of frequency mixer J3 (Fig. 36). After amplification in the high-frequency amplifier (J1 and J2) and conversion in the mixer (J3), the 19th harmonic of the crystal (for fixed frequency 57), the 20th harmonic of the crystal (for fixed frequency 101) or the 21st harmonic of the crystal (for fixed frequency 145) forms, with the heterodyne frequency f_h , the first intermediate frequency $f_{\text{in.1}} = nf_{\text{cr.}} - f_h$, the voltage of which is separated at the plate load of the mixer (J3). The first intermediate frequency $f_{\text{in.1}}$ and the second crystal harmonic $2f_{\text{cr.}} = 3.6$ Mc, amplified in the intermediate-frequency amplification system, provide (after detection) the beat tone at the output of the telephone channel. The magnitude of the frequency drift of the first receiver heterodyne can be determined according to the frequency of this tone.

With the first receiver heterodyne accurately detuned by 2.7 kc the beat frequency is audible in the first telephone channel. If, on the other hand, the beat frequency is greater than 4.7 kc, the tone is heard in the second telephone channel.

Proper operating condition of tube J4 of the crystal calibrator is checked by indicator device ИП which is connected to cathode resistor R21 by means of switch B3 through resistor R19.

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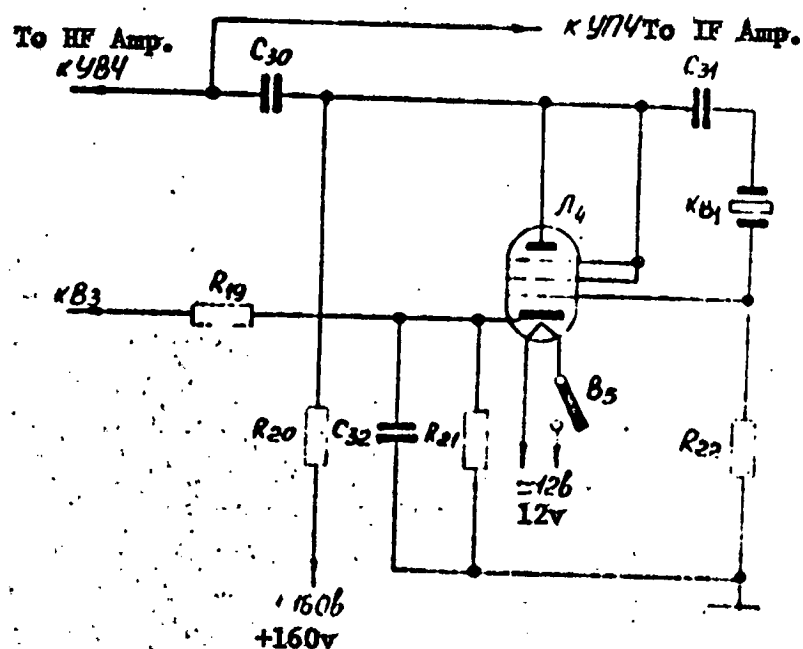


РИС. 47

Схема кварцевого калибратора

Fig. 47 Diagram of Crystal Calibrator

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Automatic Gain Control

Automatic gain control (AGC) is used in one stage of the second intermediate-frequency amplifier (УПЧ-2) with a single circuit using tube 111. AGC is effected through the use of germanium diode 3 connected to the control grid of limiter tube (112).

To the control grid of the amplifier stage (111) is fed the negative bias tapped from resistor R67 of the detector load.

Since the voltage in this resistor is proportional to the amplitude of the intermediate frequency of the signal, when the level of the latter rises on the receiving unit input, the negative bias on the control grid of tube 111 also increases. Meanwhile, there is a reduction in the amplification of stage 111, and consequently, of the entire system.

It should be borne in mind in this connection that the gain of the entire receiving system is inversely dependent on the value of the signal amplitude at the receiver input; that is, if the amplitude of the signal at the receiver input is small, the gain of the intermediate-frequency amplifier system is greater than if the amplitude of the input signal is large. However, if there is no signal at the receiver input, noise suppression is quite effective, thanks to the effect of AGC.

All these circumstances give rise to favorable conditions for more accurate operation of the AFC system of the receiver, particularly when the levels of the received signal are low.

5.

Power Amplification Section

The power amplification section is designed to increase the output power of the transmitting unit of the station to 25 watts (by 10 db). This increase in the high-frequency transmitting level of the radio link makes possible the achievement of greater operating range with the same antenna devices or higher interference resistance with range preserved. Each station equipment set contains one power amplification section.

The power amplification section comprises the following fundamental components: power amplifier, harmonic suppression filter and feed element. These components are described below.

Charts showing constant voltages and resistances of the power amplifier are given in Appendix 3.

Design of the Section

The principle design feature of the power amplification section is the front panel to which there is attached, by means of screws, a cast Silumin frame divided into a number of compartments. Contained in these compartments are the circuit elements of the section. An external view of the power amplification section is given in Figs. 48 and 49.

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The variable capacitors of the power amplifier circuits are tuned by a single control through gears. The power amplification section has no dial; it is tuned according to the readings of an indicator device located on its front panel.

The casing for the section is designed of light sheet duraluminum and is fastened to the front panel by means of screws. In the rear, the casing has an adapter for attaching the power amplification section and on the side panel there are louvers for cooling purposes. The power amplification section (in its casing) measures 335 X 300 X 130 mm and weighs 10 kg.

Power Amplifier

The power amplifier uses a type GU-50 tube (M1) with a complex parallel feed circuit (Fig. 50). The unit operates in the 60-70 Mc band. A power of not less than 1.5 watts is necessary to excite the amplifier (input impedance of the amplifier is approximately 75 ohms). Practical efficiency of the power amplifier is 30-40% (Fig. 50).

Coupling with the input circuit L1-C1 is direct and through an autotransformer. The input circuit L1-C1 is unity-coupled with the control grid of amplifier tube 1 through isolating capacitor C2.

Combined bias is fed to the control grid of tube M1. Through high-frequency choke L2 (with resistor R8) a fixed negative bias in the order of 80 volts is fed from special rectifier A3. The presence of this fixed bias limits the plate current of tube M1 when there is no excitation.

Automatic bias also occurs when excitation is caused by the grid current of tube M1 flowing across resistors R2 and R8. The resultant bias on the control grid of tube M1 with respect to its cathode (frame) in working mode is about -120 volts. The amplitude of the grid current of the power amplifier is checked by an indicator device connected (by means of switch B1 and through resistor R6) to resistor R2, through which flows the grid current of tube M1. The output circuit L4-C8 of the power amplifier is coupled with the plate of tube M1 through high-voltage isolating capacitor C7. The antenna is directly coupled through an autotransformer with output circuit L4-C8. The presence of oscillations at the output of the transformer is checked by means of the indicator device. This device is connected (by means of switch B1 through duct capacitor C14 and resistor R3) to germanium diode M1 which is loosely coupled with the power amplifier output.

The plate voltage to tube 1 of the power amplifier is fed through measuring resistor R5 and high-frequency choke L3. The value of the plate voltage is checked by means of the indicator device which is connected to the plate circuit of tube 1 by means of switch B1 through resistor R4. The amplitude of the plate current of tube M1 is checked by means of the same indicator connected (by switch B1 and over resistor R7) to measuring resistor R5 through which passes the current of tube M1.

C3, C4, C5 and C6 are blocking capacitors.

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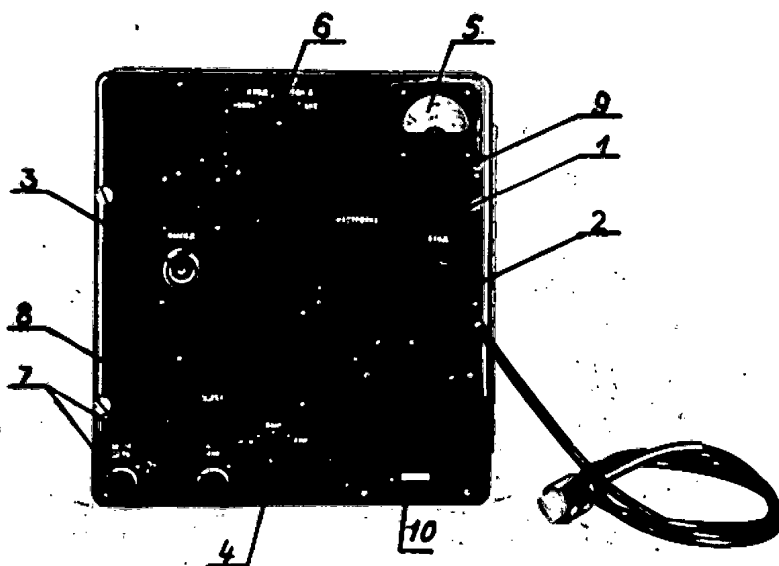


FIG. 48 - Power Amplification Section

- | | |
|---------------------------------------|-------------------------------|
| 1. Tuning Control with Setting Device | 6. Indicator Switch (B_1) |
| 2. Input Cable | 7. Power Plugs |
| 3. Output Plug | 8. Fuse (npl) |
| 4. Power Selection Switch (B_2) | 9. Forward Panel |
| 5. Indicator Device | 10. Identification Shield |

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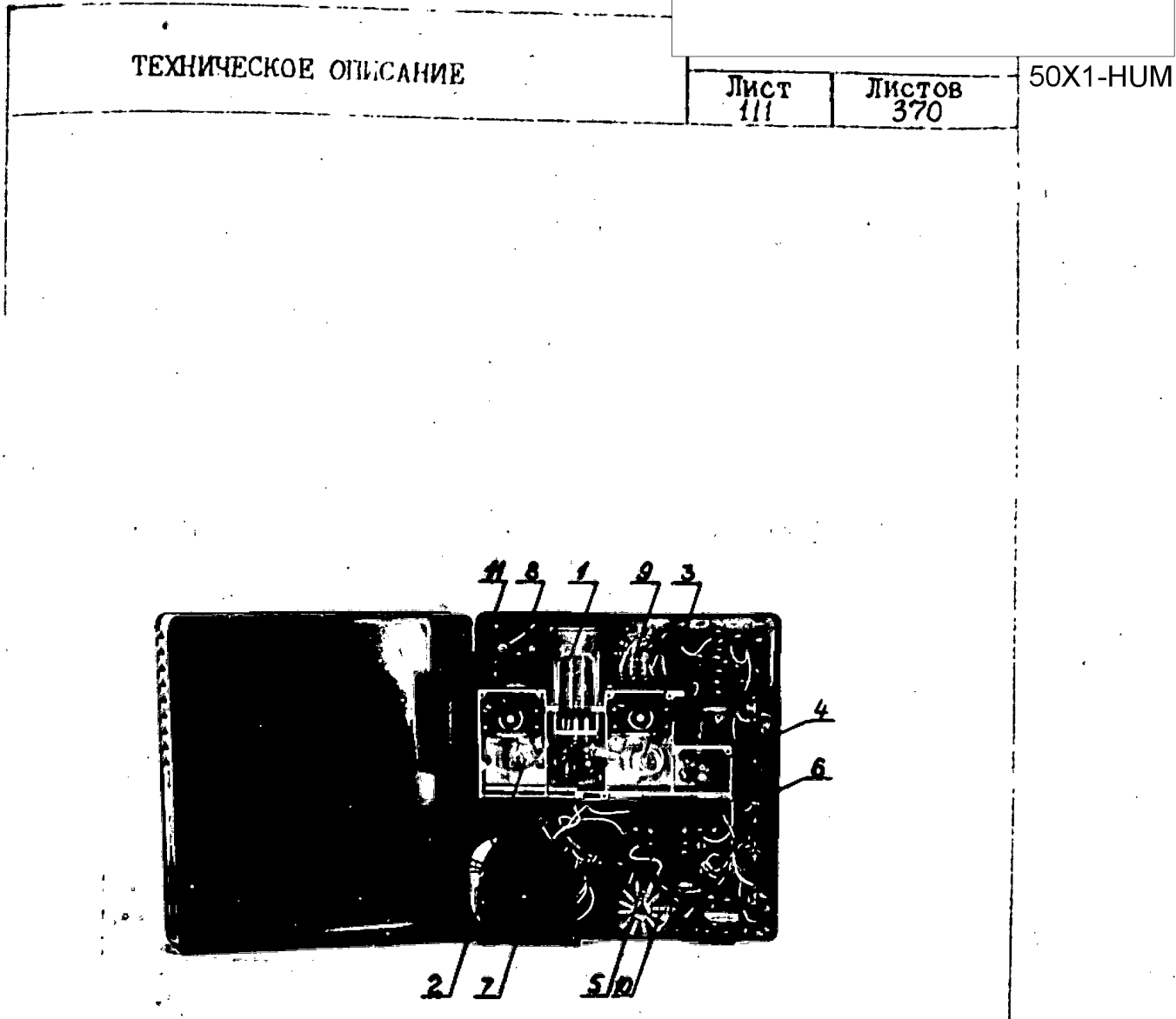


FIG. 49 - Rear View of Power Amplification Section
with Case Removed

- | | |
|------------------------------|----------------------------|
| 1. GU-50 Tube | 6. Germanium Diode |
| 2. Grid Circuit Compartment | Mounting Plate |
| 3. Plate Circuit Compartment | 7. Power Transformer |
| 4. Harmonic Suppression | 8. Indicator Device |
| Filter Compartment | 9. Indicator Switch |
| 5. Germanium Triode | 10. Power Selection Switch |
| Mounting Plate | 11. Forward Panel |

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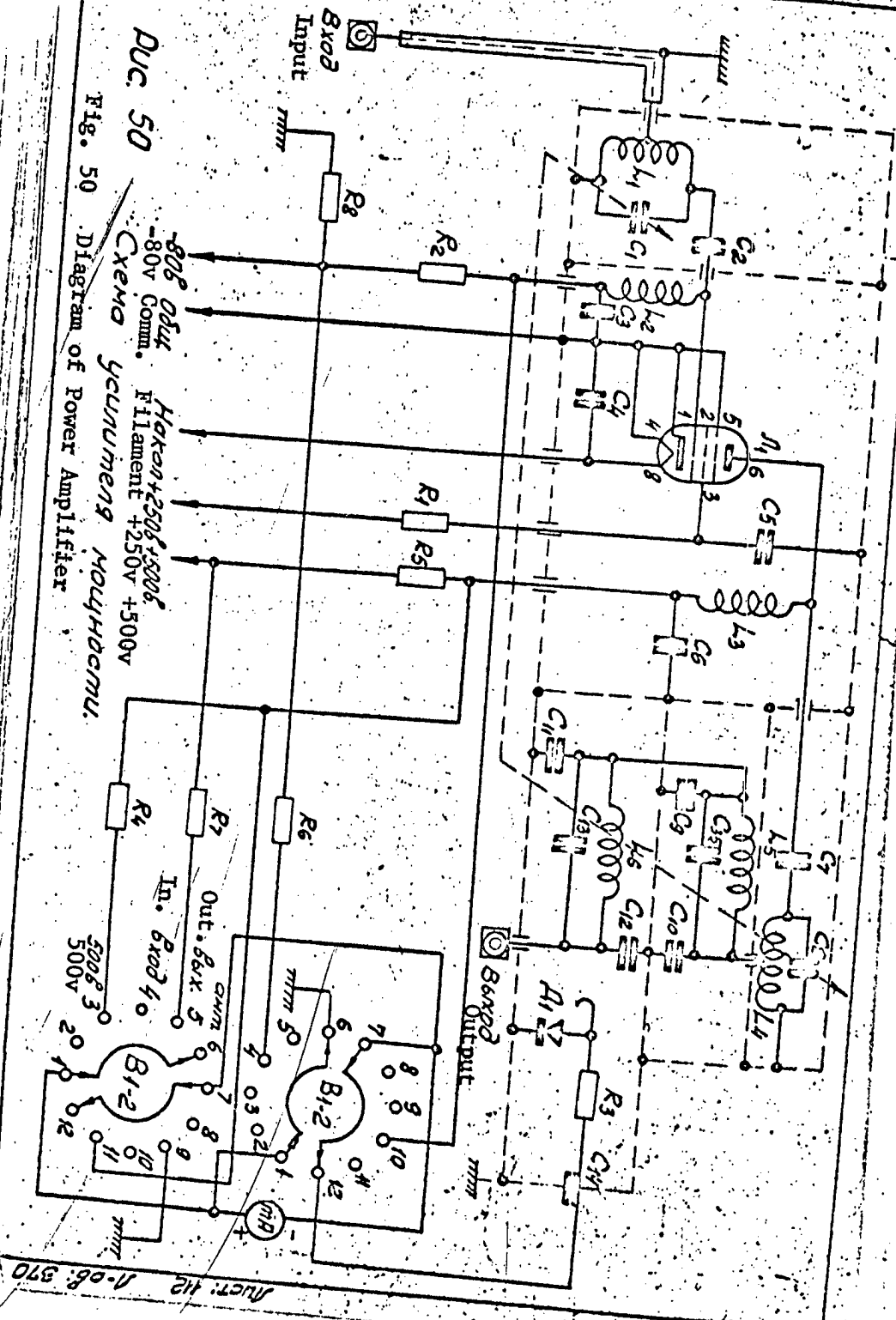


Fig. 50. Diagram of Power Amplifier

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Harmonic Suppression Filter

For the suppression of harmonic currents arising during the process of amplification of the fundamental frequency current, a filter is connected to the output of the power amplifier. This filter consists of two Pi-sections. Used as the series element in each section are parallel circuits which form attenuation bands. In the first section, parallel circuit L5-C35 forms an attenuation band for the second harmonic current (it is tuned to a frequency of 138 Mc), while, in the second section, parallel circuit L6-C13 forms an attenuation band for the third harmonic current (it is tuned to a frequency of 195 Mc). Since parallel circuits near the resonance frequency possess very large impedances, many times greater than the characteristic impedance of the antenna transmission line, the currents of the fundamental frequency harmonics will, in actual practice, not pass to the antenna. On the other hand, for the currents of the fundamental frequency in the 60-70 Mc band this filter is transparent; that is, these currents reach the antenna with low attenuation. The filter provides harmonic suppression in which the ratio of the current of the fundamental frequency to that of any harmonic at the filter output is not less than 40 db.

6.

Telephone Channel Section

Mounted in the telephone channel section are those circuit elements which pertain to the first and second telephone channels of the station and also the speak-buzz unit (NBV), the ringing generator (RTB), the pole changer (TB) and the noise-suppression filter. These components are described below. Charts showing the constant voltages and impedances of the telephone channel section are given in Appendix 3. A basic diagram of a telephone channel section is given in Volume 2.

Design of the Section

The principle feature in the design of the telephone channel section is the cast Silumin mounting rack to which is fastened, by means of screws, a cast Silumin panel and the individual components of the section. An external view of the telephone channel section is given in Figs. 51 and 52.

The individual components of the section are electrically linked with the circuit of the section by means of adapter connecting blocks. The most important section components (filters, oscillator circuits and transformers) are enclosed in hermetically sealed shields. The design of the telephone channel section provides for replacement of all tubes from the upper, right and left sides of the section.

The section casing is designed of light sheet duraluminum and has on its rear wall openings for connecting plugs and guide bushings.

The telephone channel section measures 165 X 380 X 425 mm and weighs 23 kg.

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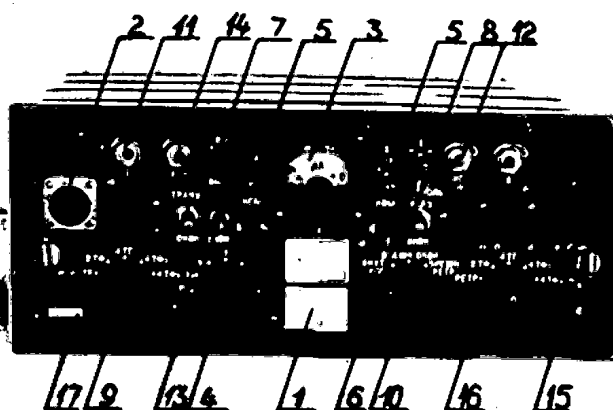
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FIG. 51 - Telephone Channel Section

1. Relay ПН-5 of Ringing Receivers
2. Operator's Set Adapter Block
3. Indicator Device
4. Indicator Switch (B_8)
5. Telephone Channel Speech Keys (K_1, K_4)
6. Telephone Channel Monitoring Key (K_2)
7. Ringing Key (K_3)
8. Attenuation Pad Switches (B_2, B_6)
9. Telephone Channel Operation Selecting Switches (B_1, B_5)
10. Station Operating Mode Switch (B_4)
11. Reception Level Adjusting Potentiometers (R_{23}, R_{36})
12. Test Level Adjusting Potentiometer (R_{37})
13. Single-Channel Operating Switch (B_9)
14. Transmission Level Adjusting Potentiometer for External Multiplexing (R_{29})
15. Catches for Fastening Section to Case
16. Forward Panel
17. Identification Shield

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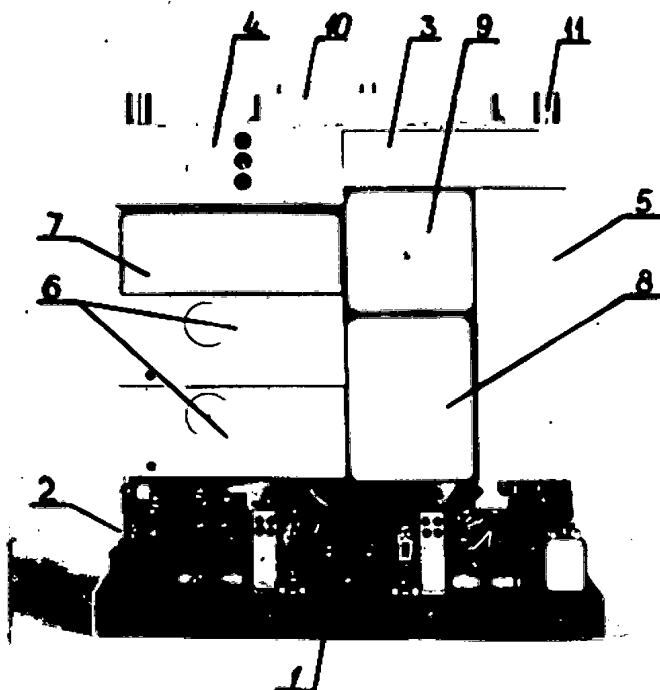


FIG. 52 - Upper View of Telephone Channel Section
with Case Removed

1. Forward Panel with its Associated Units
2. Section Frame
3. Noise-Suppression Filters
4. Pole Changer
5. Second Telephone Channel Conversion Element
6. Telephone Channel LF Elements
7. Low-Pass Filters
8. Band Filters
9. Relay Block
10. Adapter Connecting Blocks
11. Guide Bushings

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First Telephone Channel

The first telephone channel is an audio channel which passes speech frequencies without conversion. The effectively transmitted frequency band over this channel extends from 300 to 2700 kc.

Fig. 53 shows a block diagram of the first telephone channel. In this figure switching is shown for an operational situation under terminal two-wire conditions with internal multiplexing.

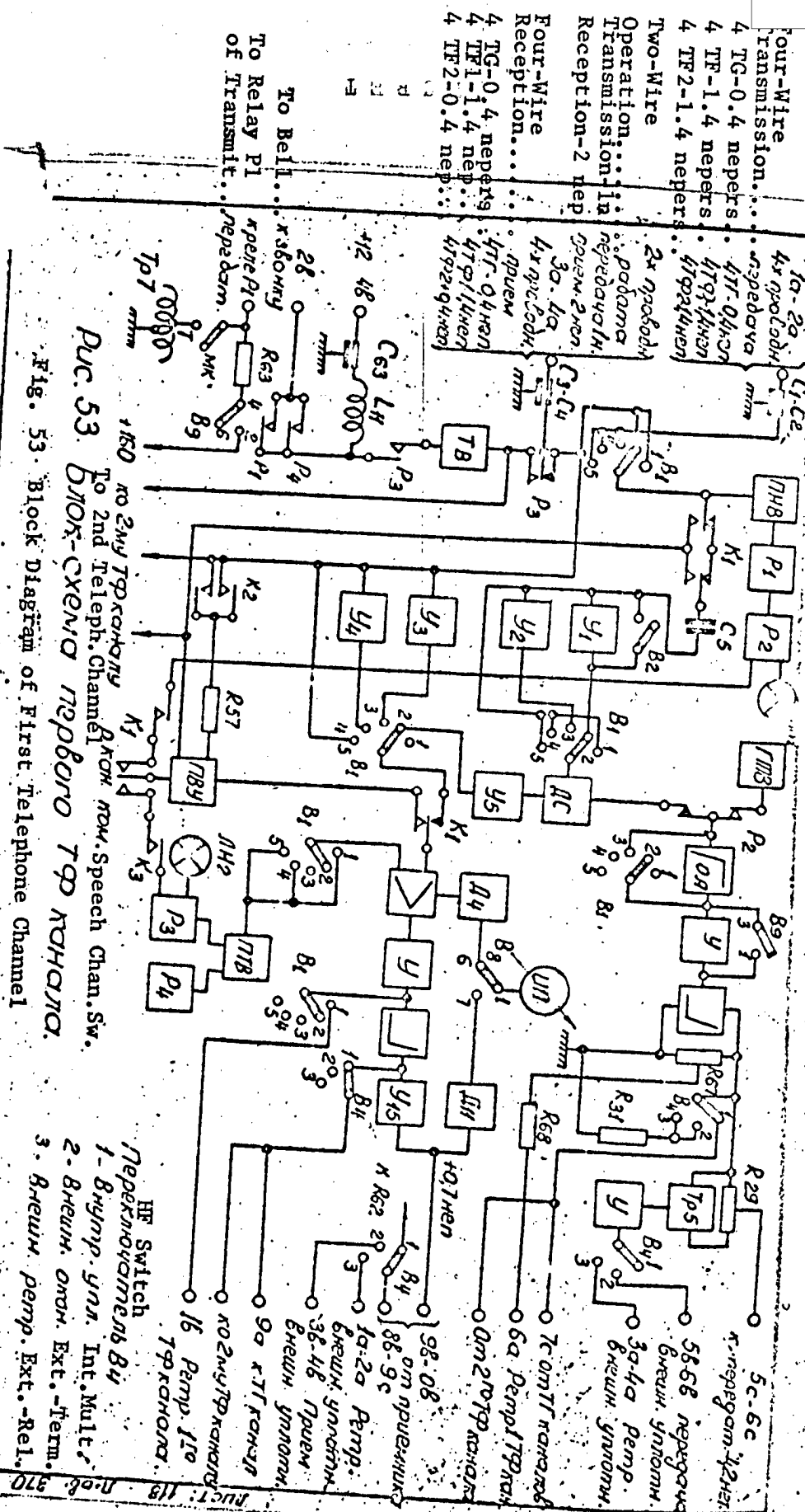
We shall consider the operational principle of the first telephone channel (Fig. 53).

Two-Wire Operation

From the switchboard or subscriber the signal travels over the two-wire connecting line through the line board (these elements are not shown on the diagram) and reaches contacts 3a-4a (5a-6a*) of adapter block $\Pi K-1$ of the telephone channel section. Further, the signal passes through duct capacitors C3-C4 (C26-C27) of the noise filter, relay contacts P3 (P10), the contacts of channel operation selecting switch B1 (B5), the contacts of speech key K1 (K4), isolating capacitor C5 (C28), attenuation network Y1 (Y6) with an attenuation of 0.6 nepers, the contacts of switch B1 (B5) and reaches the differential system (hybrid) ΔC . The differential system (hybrid) is used for the transition from the two-wire subscriber line to the four-wire circuitry of the channel. Having passed through differential system (hybrid) ΔC , the signal travels through contacts B2 (P9), amplitude limiter OA, attenuation network Y (consisting of resistors with a 1.8 neper attenuation) and low-frequency filter $\Phi H \Psi$ with a passband to 2700 kc, reaching contacts 5c-6c of adapter block $\Pi K-1$. From these contacts the signal reaches the input of the transmitter modulation amplifier (see Section 4 of this chapter). Fed to these same contacts through switch B4 are the signals transmitted over the second telephone channel and the telegraph channels (the signals from the telegraph channels reach the telephone channel section through contact 7c of adapter block K-1).

In two-wire operation the signal, fed to the telephone section input with a level of -1 neper, reaches the input of the transmitter modulator amplifier with a level of -4.2 nepers. If the input level of the signal is greater than -1 neper the amplitude limiter limits the amplitude of the transmitted signal within a given range. This eliminates overmodulation of the transmitter by the telephone channel signal and reduces crosstalk to the other channels. The amplitude limiter, since it is a nonlinear element, introduces nonlinear distortions into the signal transmitted over the channel. However, the nonlinear distortions thus introduced impair the quality of communication far less than the interaction between channels when there is no limiter. The presence in the transmitting branch of the first telephone channel of low-frequency filter $\Phi H \Psi$ also eliminates the possibility of interference from this channel to the others.

* The numbers given in the parentheses refer to the corresponding components for the second telephone channel.



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The received signals pass from the output of the radio receiver to the telephone channel section reaching contacts 9B-0B of adapter K1. The level of the signal being received may be checked by means of indicator device ИП. For this purpose the indicator device is attached to contacts 9B-0B through contacts 1-7 of switch B8 and the rectifier unit using germanium diode Δ11.

Having passed through attenuation network Y15 (attenuation = 0.5 nepers), the received signals are bifurcated. The signals transmitted over the second telephone channel are directed into the receiving branch of the second telephone channel circuit. The signals transmitted over the telephone channels reach contact 9a of adapter П K1.

The signals transmitted over the first telephone channel pass through low-frequency filter ФНЧ with a passband to 2700 cycles and attenuation network Y consisting of resistors with a 1.8 neper attenuation to the input of low-frequency amplifier УНЧ. The presence of low-frequency filter ФНЧ at the input of the receiving branch of the first telephone channel eliminates possible interference from the other channels. From the output of low-frequency amplifier ФНЧ the signal reaches contacts 3a-4a (5a-6a) of adapter K1, passing through the contacts of speech key K1 (K4), contacts of switch B1 (B5), attenuation network Y5 (attenuation = 1.6 nepers), differential system (hybrid) ΔC, the contacts of switch B1 (B5), attenuation network Y1 (Y6), isolating capacitor C5 (C28), the contacts of speech key K1 (K4), the contacts of switch B1 (B5), the contacts of relay P3 (P10), duct capacitors C3-C4 (C26-C27) of the noise-suppression filter. Further, the received signal passes through the line board (not shown in Fig. 48) over the two-wire line to the switchboard or to the subscriber. The level of the signal received over the first telephone channel is checked by means of indicator device ИП which is attached to the output of low-frequency amplifier УНЧ through contacts 1-6 of switch B8 and the rectifying unit built around germanium diode Δ4.

With the channel coupled over a two-wire circuit, attenuation network Y1 (Y6) is disconnected by means of switch B2 (B6) in order to reduce residual attenuation in the coupled channel.

Let us trace the passage of a call. The magneto ringing signal with a frequency of 16-25 cycles, incoming over the two-wire line from the switchboard or the subscriber, cannot be directly transmitted by radio since the passband of the radio channel is 300-16,000 cycles. Consequently, the magneto ringing signal (16-25 cycles) is converted into a ringing signal of 800-cycles frequency, which is passed by the radio channel. Let us observe how this takes place. Having reached contacts 3a-4a (5a-6a) of adapter П K1 the magneto ringing signal, passing through duct capacitors C3-C4 (C26-C27), the contacts of relay P3 (P10) and the contacts of switch B1 (B5), reaches the magneto ringing receiver ПИВ. Relays P1 (P3) and P2 (P9) operate, green signal lamp ЛН1 (ЛН3) flashes, ringing generator ГТБ is connected to the transmitting branch of the channel, and the 800-cycle ringing signal is directed to the modulation amplifier of the transmitter. The transmitting branch of the channel is disconnected from the differential system (hybrid) by means of the contacts of relay P2 (P9). Simultaneously, with the operation of relay P1 (P9), +12 volts is fed through its contacts to the bell (contact 2B of adapter П K1).

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From the output of the radio receiver the 800-cycle ringing signal reaches the low-frequency amplifier $\Psi H4$ in the same manner as the speech frequency current (see above). Connected to the plate circuit of tube $\Lambda 1$ ($\Lambda 2$) of this amplifier is the voice-frequency ringing receiver $\Pi T B$ which, when acted upon by the a-c 800-cycle voltage, connects relay P3 (P10). When this relay operates, red signal lamp $\Lambda H2$ ($\Lambda H4$) flashes and +12 volts is fed through noise-suppression filter C63-L11 and the contacts of relay P3 (P10) to pole changer TB. The pole changer begins to operate and the 25-cycle magneto ringing signal passes through the contacts of relay P3 (P10), duct capacitors C3-C4 (C26-C27), and contacts 3a-4a (5a-6a) of adapter $\Pi K1$ to the two-wire line leading to the switchboard or subscriber. The bell, in this case, does not ring at the station.

Four-Wire Operation without Relay of Magneto Ringing

This mode of operation of the telephone channel is designed for secondary multiplexing of the channel by voice-frequency telegraphy equipment (for example, P-313). In this case the channel operation selecting switch B1 (B5) is set in position 3 (4Tf). With a four-wire connection of the channel, contact pair 3a-4a (5a-6a) of adapter $\Pi K1$ is used for reception, while the additional contact pair 1a-2a (1c-2c) of the same adapter is used for transmission. Let us consider the path of the signals in this form of operation.

The transmitted signal is fed to the input of differential system (hybrid) ΔC from contacts 1a-2a (1c-2c) through duct capacitors C1-C2 (C24-C25), the contacts of switch B1 (B5), the contacts of speech key K1 (K4), isolating capacitor C5 (C23), attenuation pad Y2 (Y7) with an attenuation of 1.1 nepers, and the contacts of switch B1 (B5). In this mode, amplitude limiter OA is disconnected from the transmitting branch by means of switch B1 (B5) in order to reduce the nonlinear distortions in the channel. From the output of the differential system (hybrid) the signal passes through the contacts of relay P2 (P9), pad Y with an attenuation of 1.8 nepers, low-frequency filter $\Phi H4$, and contacts 5C-6C of adapter $\Pi K1$ to the input of the modulation amplifier of the transmitter.

The received signal passes from the radio receiver output to the input of the low-frequency amplifier in the same manner as in two-wire operation (see above). From the output of the low-frequency amplifier the signal passes through the contacts of speech key K1 (K4), the contacts of switch B1 (B5), pad Y3 (Y8) (with an attenuation of 1 neper), the contacts of relay P3 (P10) and duct capacitors C3-C4 (C26-C27) to the receiving contacts 3a-4a (5a-6a) of adapter $\Pi K1$. In this mode, the voice-frequency ringing receiver $\Pi T B$ is disconnected from the receiving branch of the channel by switch B1 (B5).

With a four-wire channel connection with no magneto ringing relay (mode 4Tf) the rated values of the transmitting and receiving levels equal -0.4 nepers.

Four-Wire Operation with Magneto Ringing Relay in Mode 4T01

This system of operation is employed with the channel coupled over a four-wire circuit to wire and radio relay communication channels which, when connected over four wires, provide for relay of magneto ringing. In this case, channel operation selecting switch B1 (B5) is set in position 4 (4T01). Let us consider the passage of the speech and ringing signals in this mode of operation. The

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transmitted signal reaches the input of differential system (hybrid) ΔC from contacts 1a-2a (1c-2c) through duct capacitors C1-C2 (C24-C25), the contacts of switch B1 (B5), the contacts of speech key K1 (K4), isolating capacitor C5 (C28) and the contacts of switch B1 (B5). From the output of the differential system the signal reaches the input of the transmitter modulation amplifier in the same manner as when the channel is worked over two wires (see above).

Reaching contacts 1a-2a (1c-2c), the magneto ringing signal passes through duct capacitors C1-C2 (C24-C25) and the contacts of switch B1 (B5) to magneto ringing receiver $\Pi M B$. In this case, just as in two-wire operation, the green signal lamp $\lambda H1$ ($\lambda H3$) glows, the bell rings and from the ringing generator ΓTB an 800-cycle ringing signal is fed to the input of the modulation receiver of the transmitter (contacts 5c-6c of adapter $\Pi K1$).

The signals received by the radio receiver - for speech and ringing - reach the input of the low-frequency amplifier $\gamma M \gamma$ from contacts 9B-0B of adapter $\Pi K1$, as described above. From the low-frequency amplifier output the speech signal passes through the contacts of speech key K1 (K4), the contacts of switch B1 (B5), pad Y4 (Y9) (with an attenuation of 2 nepers), the contacts of relay P3 (P10), and duct capacitors C3-C4 (C26-C27) to contacts 3a-4a (5a-6a) of adapter $\Pi K1$.

From the output of low-frequency amplifier $\gamma M \gamma$ the ringing signal with a frequency of 800 cycles reaches the voice-frequency ringing receivers $\Pi M B$. Here, just as in two-wire operation, red signal lamp $\lambda H2$ ($\lambda H4$) flashes and the magneto ringing signal reaches contacts 3a-4a (5a-6a) of adapter $\Pi K1$ from pole changer TB.

In four-wire operation with magneto ringing relay in mode 4T01 the rated values of the transmission and reception levels equal -1.4 nepers.

Four-Wire Operation with Magneto Ringing Relay in Mode 4T02

This mode of operation is employed when the channel is coupled over a four-wire circuit with channels requiring a higher level on the reception side. In this case, channel operation selecting switch B1 (B5) is set in position 5 (4T02).

In this type of working, the passage of the signals (speech and ringing) in the direction of transmission from contacts 1a-2a (1c-2c) to the input of the modulation amplifier of the transmitter (contacts 5c-6c of adapter $\Pi K1$) and the passage of the ringing signal from the output of the radio receiver (contacts 9B-0B) to contacts 3a-4a (5a-6a) is the same as with four-wire operation in the 4T0 mode. The difference in the passage of the speech signal over the receiving branch of the channel consists in the fact that the received speech signal passes from the output of low-frequency amplifier $\gamma M \gamma$ through the contacts of speech key K1 (K4), the contacts of switch B1 (B5), the contacts of relay P3 (P10) and duct capacitors C3-C4 (C25-C27) to contacts 3a-4a (5a-6a) of adapter $\Pi K1$, bypassing the attenuation pads. For this reason, with four-wire operation and magneto ringing relay in the 4T02 mode, the rated value of the transmission level remains as before (-1.4 nepers).

Channel Operation in the Relay Mode

Channel relay at an intermediate station is effected over a four-wire system. For this purpose the channel operation selecting switch B1 (B5) is set in position 1 (PETP; that is, "RELAY"). In this case, the signals (speech and ringing), picked

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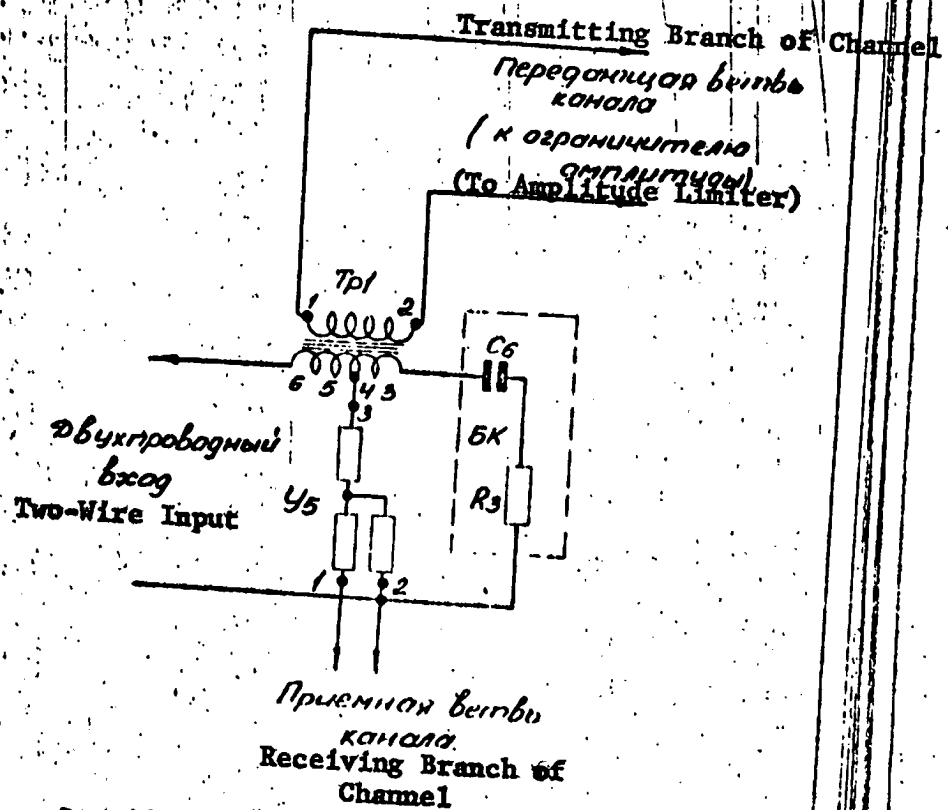


Рис. 54 Упрощенная схема дифференциальной системы

Fig. 54 Simplified Diagram of Differential System (Hybrid)

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up by the radio receiver of a particular half-set, pass from the receiving branch of the channel (from the output of low-frequency filter $\Phi H \Gamma$) through switch B1 (B5) to contact 1B (2B) of adapter K2 and are further led into the transmitting branch of the first (second) telephone channel of the other half-set. In order to permit calling of the intermediate station, the low-frequency amplifier $\Psi B \Gamma$ in the receiving branch of the channel remains connected with the voice-frequency ringing receiver $\Pi T B$.

The signals (speech and ringing) received by the receiver of the other half-set, pass from contact 6a (8a) of adapter K2 through resistor R63 (R70) and potentiometer R67 (R69) to the input of the modulation amplifier of the transmitter (contacts 5c-6c of adapter $\Pi K 1$). In this way, with relay operation, the signals at the intermediate station pass through only one filter connected in the receiving branch of the channel.

The individual components of the first telephone channel are described below.

Differential System (Hybrid)

The differential system (hybrid) is used for the transition from a two-wire subscriber line to the four-wire circuit of the radio channel. Its purpose is to permit the passage of speech currents from the switchboard or subscriber only in the direction of the modulation amplifier of the transmitter, and the passage of speech currents from the radio receiver only in the direction of the switchboard or subscriber.

In terms of its design, the differential system (hybrid) is located in the low-frequency element of the telephone channel and consists of differential transformer Tpl and balancing network R3-C6 (Fig. 54).

The operational principle of the differential system (hybrid) consists in the following:

The transmitted signal from the switchboard or subscriber reaches contacts A-OC of adapter $\Pi K 8$ ($\Pi K 9$) of the low-frequency element. Further, the current circuit is closed through primary winding 3-6 of differential transformer Tpl and balancing network R3-C6. The current, passing through primary winding 3-6, will induce emf in the secondary winding 1-2 of differential transformer Tpl. Subsequently, the signal reaches the transmitting branch of the channel. The attenuation, introduced by the differential system (hybrid) in the switchboard-transmitter direction, stands at about 0.4 nepers.

The received signal from the output of the low-frequency amplifier $\Pi 1$ ($\Pi 2$) reaches contacts OB-OC of adapter K8 (K9) and pad Y5 (contacts 1 and 2). At the output of pad Y5 (contacts 2 and 3) the current of the received signal is bifurcated in two directions. A part of the current flows through primary winding 6-5 and the two-wire line leading to the switchboard or subscriber, while a second part of the current flows through primary winding 4-3 and balancing network R3-C6. The impedance of the balancing network is chosen so as to be equal to the characteristic impedance of the two-wire line; as a result, the currents flowing through windings 3-4 and 5-6 of the differential transformer will be equal. However, since these currents flow through the primary winding in different directions, the resultant magnetic flux in the core of differential transformer Tpl will equal zero.

Consequently, there will be no induced emf in secondary winding 1-2 of this transformer and the received signals will not penetrate into the transmission branch of the channel. The attenuation introduced by the differential system (hybrid) in the receiver-- switchboard direction stands at about 0.4 nepers and in the receiver - transmitter direction at about 4-5 nepers.

Amplitude Limiter

The amplitude limiter, which is connected in the transmission branch of the channel at the output of the differential system (hybrid), serves to eliminate transmitter overmodulation in the face of strong signals incoming from a switchboard or subscriber.

In terms of its design, the amplitude limiter is located in the low-frequency element of the telephone channel and mounted in a T-shaped circuit containing transformer Tp2 and two pairs of germanium diodes $\Delta 2$ and $\Delta 3$ (Fig. 55a).

The equivalent circuit of the amplitude limiter (Fig. 55b) has the form of a T-shaped pad consisting of nonlinear resistances, the value of which depends on the voltage fed to the input.

The operational principle of the amplitude limiter consists in the following:

As the input voltage increases, due to the effect of germanium diodes $\Delta 2$ the impedance introduced from the secondary winding 1-2 to the primary 3-6 of transformer Tp2 increases. This is tantamount to an increase in the series resistances in the equivalent circuit. As the voltage fed to the input increases, there is also an increase in the current flowing through germanium diodes $\Delta 3$, which is equivalent to a reduction of the parallel resistance in the equivalent circuit. In this way, as the voltage increases at the input of the amplitude limiter, its equivalent series resistances increase, while its parallel resistance decreases, because of which the voltage at the output of the limiter remains at a practically constant value.

In order that the amplitude limiter begin to function, in the manner described above, only in the case of an input voltage level higher than the rated, positive bias is fed to germanium diodes $\Delta 2$ from contact 3B of adapter NK2 through noise-suppression filter P4-C61-C62, contact 7B of adapter NK8 (NK9) and through resistors R5, R6 and R7.

For reduction of nonlinear distortions in the event a telephone channel is used for voice-frequency telegraphy (mode 4Tf), the amplitude limiter is switched off by means of switch B1 (B5). In this case, diodes 3 are disconnected and winding 1-2 of transformer Tp2 is shunted by resistor R4, the amplitude limiter thus becoming a conventional pad with a linear impedance and having an attenuation in the order of 0.1 nepers.

Low-Frequency Amplifier

The low-frequency amplifier is designed for inclusion in the low-frequency element of the telephone channel and employs a type 12Zh1L tube $\Delta 1$ ($\Delta 2$) in a transformer circuit (Fig. 56).

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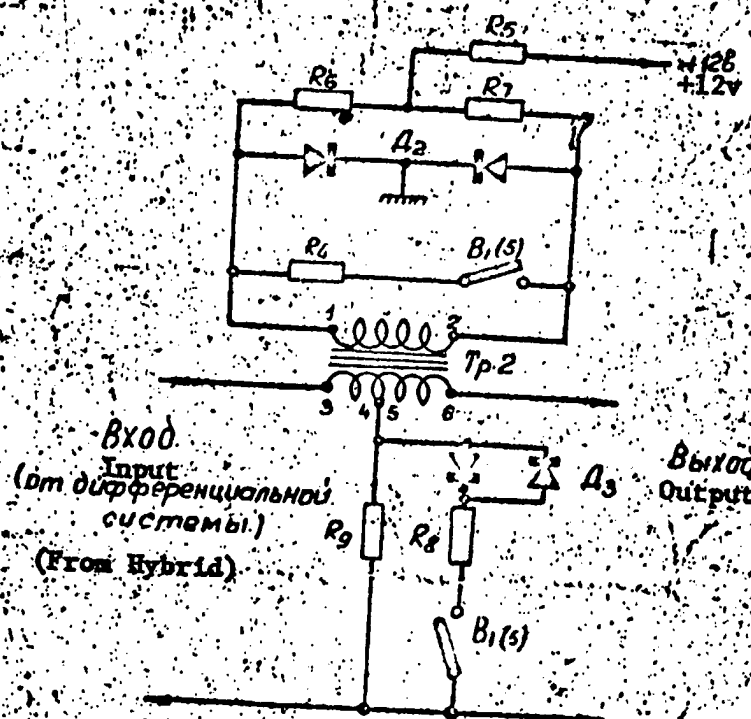


Рис. 55а

Схема ограничителя амплитуды

Fig. 55a Diagram of Amplitude Limiter

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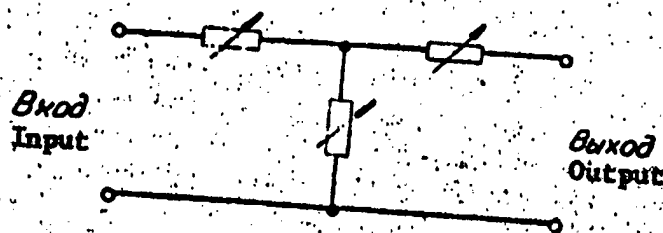


Рис. 55б Эквивалентная схема ограничителя.

Fig. 55b. Equivalent Circuit Diagram of Limiter

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The signal voltage is fed from potentiometer P20 (P36) to the control grid of amplifier tube $\mu 1$ ($\mu 2$) through input transformer Tp4. The potentiometer is used to set the receiving level at the output of the telephone channel when the latter is adjusted. The control for this potentiometer is remoted to the front panel of the telephone channel section under the slot (Fig. 51, No. 11).

Connected to the plate circuit of the tube is output transformer Tp3, used in the further transmission of received speech signals. The output winding 5-6 of this transformer is connected by means of switch B1 (B5) either to the differential system (hybrid) in the case of two-wire operation of the channel or to contacts 3a-4a (5a-6a) of adapter K1 in four-wire operation. The same winding is connected through contacts 11-12, 14-15, 29-30 of key K1 (K4) and resistor R10 to the earphones T of the operator's set when speech key K1 (K4) is set in position P.KAH ("SPEECH CHANNEL").

The signal level at output is checked by means of indicator device $\mu \mu$ which is connected to the output winding 5-6 of transformer Tp3 through contacts 1-6 (1-5) of switch B8, conductors Δ -6 (δ -r), germanium diode Δ 4, resistors R11 and R12 and potentiometer R13. Potentiometer R13 is used for factory adjustment of indicator device $\mu \mu$.

Negative current feedback, formed by virtue of the fact that cathode resistors R16-R18 are not capacitance-shunted, is employed in the low-frequency amplifier.

Low-frequency correction is provided in this amplifier. Capacitor C13 and primary winding 1-2 of input transformer Tp4 form a series oscillatory circuit tuned to a frequency of 300 cycles. In this way there is attained a reduction in the slope of the frequency response characteristic in the area of the lower frequencies of the speech spectrum.

Proper operating condition of tube $\mu 1$ ($\mu 2$) is checked by means of indicator device $\mu \mu$ which is connected to small cathode resistor R18 through contacts 1-10 (1-10) of switch B8. C11 and C12 are blocking capacitors.

Ringling Receiver

Design-wise, the voice-frequency ringling receiver is located in the low-frequency element of the telephone channel and is represented by a double-circuit discriminator (Fig. 56). Circuit L1-C9 is tuned to a frequency of 800 cycles (the operational call signal), while circuit L2-C10 is tuned to a frequency of 930 cycles (the service call signal). Inductively coupled with these circuits are full-wave rectifiers Δ 5 and Δ 6 using germanium diodes. The load of rectifier Δ 5 is winding 11-7 of polarized relay P5 (P12) of type RP-5, while the load of rectifier Δ 6 is winding 1-10 of the same relay. By means of resistor R33, the current in winding 11-7 is selected so as to be equal to the current flowing through winding 1-10, with the current in both these windings flowing in opposite directions. Fig. 57 shows curves illustrating the dependence of the currents in these windings on the frequency of the signal fed to the low-frequency amplifier input (Fig. 57).

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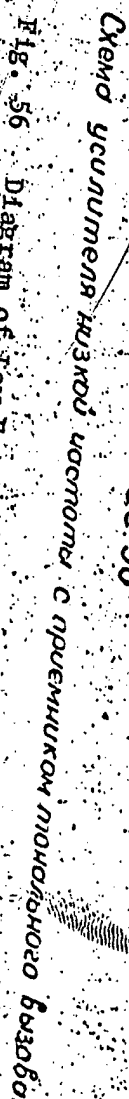


Fig. 56 Diagram of Low-Frequency Amplifier with Voice-Frequency Ringing Receiver

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The circuit of the voice-frequency ringing receiver operates as follows: with the receipt of an operational call (an 800-cycle signal), the current in winding 11-7 of polarized relay P5 (P12), connected to circuit L1-C9 which is tuned to the operational call frequency of 800 cycles, will be many times greater than the current flowing in winding 1-10 of the same relay. As a result, armature A of relay P5 (P12) is drawn toward left contact 1. At this point, the voltage (+12 volts) is fed through K1 (K4) to relay P3 (P10). High-value capacitor C80 (C82) (700 microfarads), which is connected to winding 11-7 of relay P5 (P12), is designed to protect against the operation of relay P3 (P10) during conversations over the channels (the 800-cycle frequency falls within the conversational speech band). When relay T3 (T10) operates, the voltage (+12 volts) is fed through contacts 2-23 of this relay to the red signal lamp NH2 (NH4), and through contact 4-45 to pole changer TB (contact 1B of adapter K7). The pole changer begins to operate. The output of the pole changer (contacts 1a-2a of adapter K7) is connected to the line running to the switchboard or subscriber through contacts 12-13 and 2-23 of relay P3 (P10). At the same time, the output of the differential system (hybrid) is terminated in resistor R1 (R32) (620 ohms) by means of contacts 14-15 of this same relay.

In this way, with the receipt of an operational call (an 800-cycle signal), red signal lamp NH2 (NH4) glows and magneto ringing on a frequency of 20-30 cycles is sent to the wire line. The station bell does not ring.

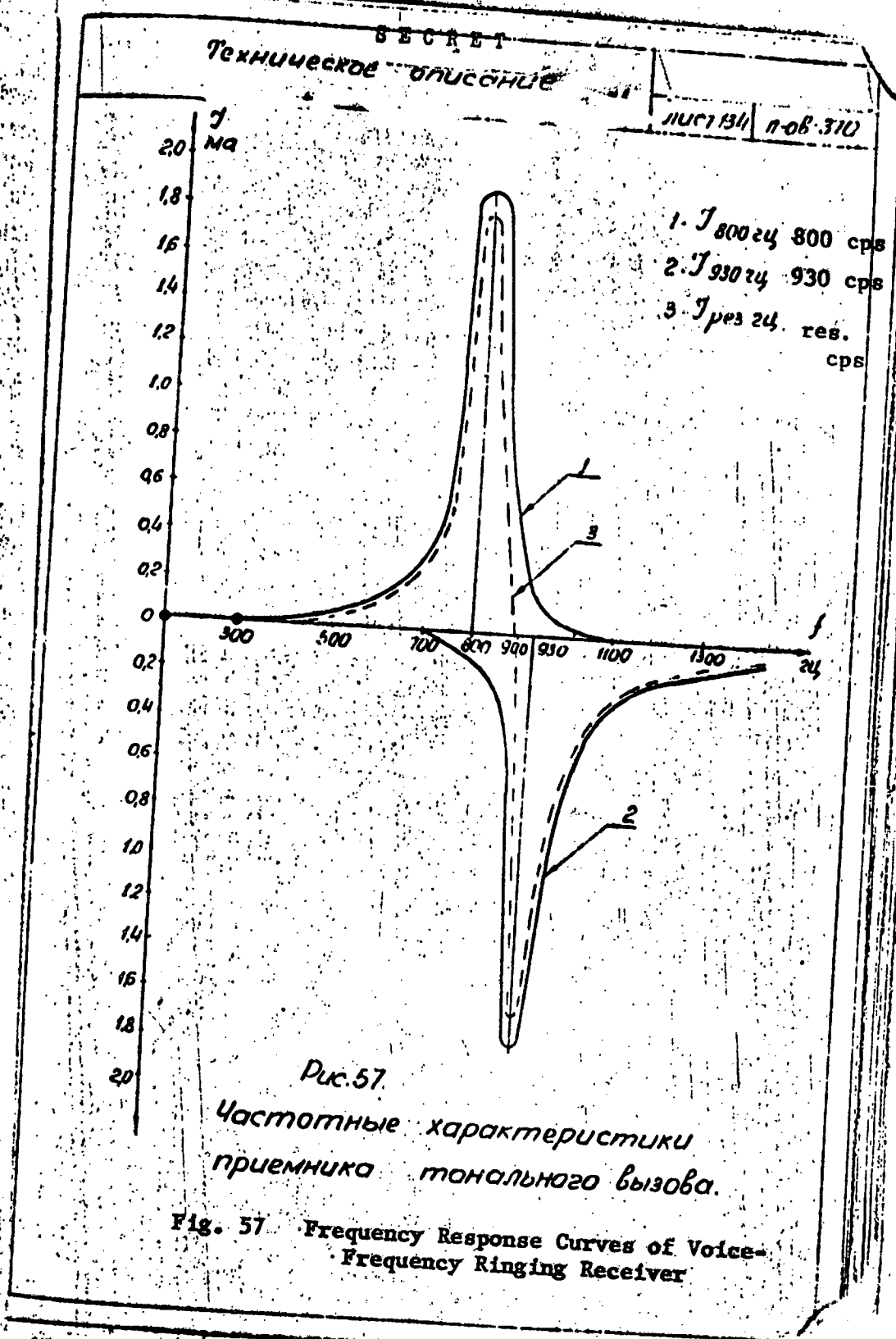
With the receipt of a service call, the current in winding 1-10 of polarized relay P5 (P12), connected with circuit L2-C10 which is tuned to the service call frequency of 930 kc, will be many times greater than the current flowing in winding 11-7 of the same relay. As a result, armature A of relay P5 (P12) is drawn to right contact 1. Meanwhile, the voltage (+12 volts) will be fed to relay P4 (P11) through armature A and right contact 1 of relay P5 (P12). Capacitor C81 (C83), connected to winding 1-10 of relay P5 (P12), is used for the same purpose as capacitor C80 (C82) in the circuit of relay P3 (P10) (operational calling). When relay P4 (P11) operates, through its contact 12-13 a voltage (+12 volts) is fed to the red signal lamp NH2 (NH4) and through contacts 11-12 to the bell (contact 2B of adapter K1).

In this way, when a service call (930-cycle signal) is received, red signal lamp NH2 (NH4) glows at the station and the bell rings. The pole changer is not switched on at this time and no magneto ringing is sent into the wire line. When the telephone channel is operated over a four-wire circuit without relay of magneto ringing (mode 4Tf), the voice-frequency ringing receiver is disconnected. This is achieved by the fact that circuits L1-C9 and L2-C10 are shorted by means of switch B1 (B5). The switching operation is carried out in such a way that, with both telephone channels set for the "4Tf" mode, the voice-frequency ringing receiver for the second telephone channel remains connected, thus providing the possibility of calling the station over this second telephone channel.

Pole Changer

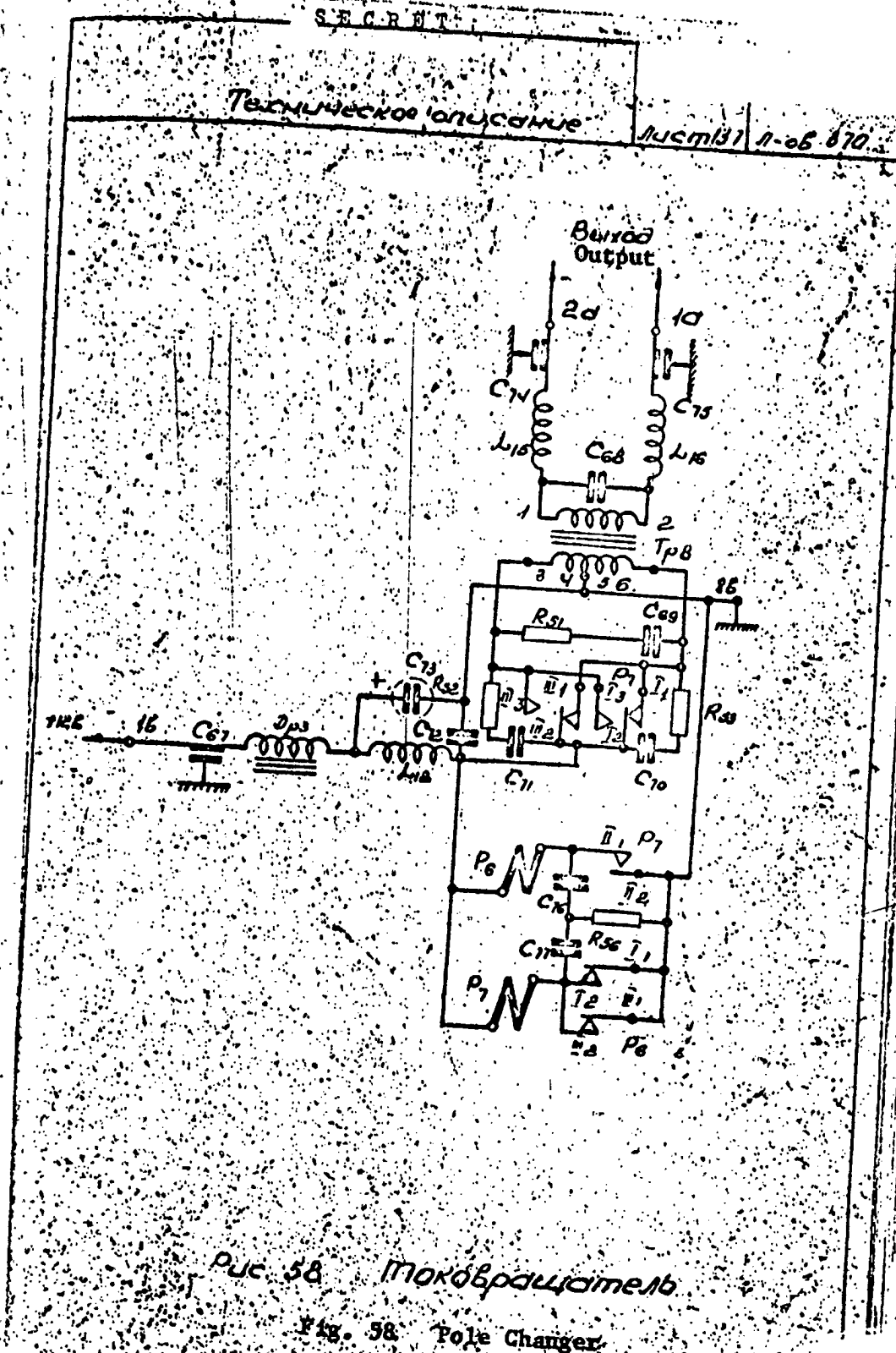
Design-wise, the pole changer is located in its own removable element and is a single unit common to both telephone channels. The pole changer consists of two relays P6 and P7 of type PKN, operating in pulse-pair, and transformer Tp8 (Fig. 58). The networks of capacitors and resistors C69-R51, C70-R53, C71-R52 and C76-C77-R56, which shunt the contacts of relays P6 and P7, are spark-quenching networks.

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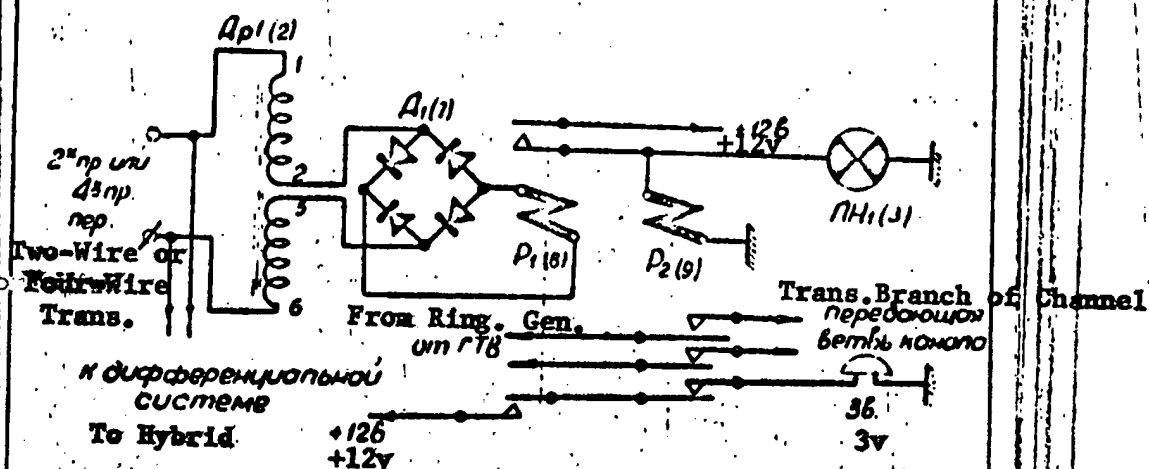


Рис 59

Схема приемника индукторного вызова.

Fig. 59 Diagram of Magneto Ringing Receiver

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Duct capacitor C67, chokes P3 and L12 and capacitors C72 and C73 form a noise-suppression filter at the input of the pole changer, while duct capacitors C74 and C75, chokes L15 and L16 and capacitor C68 form a similar filter at the output of the pole changer (Fig. 58).

The pole changer operates on 12-volt d-c voltage. When relays P6 and P7 are activated, there is an alternating current with a frequency of 20-30 cycles in secondary winding 1-2 of transformer Tp8. The pole changer provides a ringing voltage of approximately 60 volts when the output of transformer Tp8 (contacts 1a-2a of adapter ПK7) is terminated in a 2-kilohm resistance. The pole changer consumes approximately 1.1 amperes of current in its operation.

Magneto Ringing Receiver

Design-wise, the magneto ringing receivers of both telephone channels are located in the pole changer element. The magneto ringing receiver consists of choke Δp1 (Δp2) and rectifier bridge Δ1 (Δ7) using germanium diodes (Fig. 59).

The magneto ringing receiver operates as follows: magneto ringing, incoming from the line, passes through contacts 4a-5a (6a-7a) of adapter K7, winding 1-2 and 5-6 of choke Δp1 (Δp2) to rectifier bridge Δ1 (Δ7). Choke Δp1 (Δp2) serves to block the path to the rectifier bridge for the higher speech frequencies and in this way eliminates the possibility that the telephone conversation circuit be shunted. The ringing current, with a frequency of 16-25 cycles, on the other hand, freely passes through the windings of this choke. When inductor ringing is received, the current rectified by bridge Δ1 (Δ7) passes through the winding of relay P1 (P8). When this relay operates, a voltage (+12 volts) is fed through its contacts 1₁-1₂ to green signal lamp ЛН1 (ЛН3), through contacts Л1-Л2 to the bell (contact 2B of adapter ПK1) and through contacts П1 and П2 and contacts 26-25 of speech key K1 (K4) to relay P2 (P9). When relay P2 (P9) operates, by means of its contacts 1₁-1₂ the output of the differential system (hybrid) is disconnected from the transmitting branch of the channel and there is connected to the latter, by means of contacts П4-П5 and Л2-Л3, the output of the voice-frequency ringing oscillator (Л3) which provides the 800-cycle oscillations.

In this way, when magneto ringing comes in from a wire line, green signal lamp ЛН1 (ЛН3) lights, the bell rings at the station and there is sent into the radio line an 800-cycle ringing signal.

In order to prevent the reception of a ringing signal with a frequency of 800 cycles by one's own voice-frequency ringing receiver, if the differential system (hybrid) of the opposite station is unbalanced (no load on the wire line), when relay P2 (P9) operates its contacts П2-П3 disconnect the voice-frequency ringing receiver proper to the station, by shorting circuits L1-C9 and L2-C10.

Ringing Generator

Design-wise, the ringing generator is located in the second channel converter element and constitutes a single common component for both telephone channels.

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The ringing generator consists of tube J3 (type 12Zh1L) in a double-circuit arrangement with electron coupling (Fig. 60). This type of circuitry provides high frequency stability and a low effect of load resistance on the frequency generated. The frequency of the oscillations generated is determined by the internal hermetically sealed circuit C39, C40-L17. The ringing generator operates continuously on a frequency of 800 cycles. This frequency is used to transmit a call from the subscriber (or from a station) to a switchboard (operational calling).

When a service call is sent, contacts 4-5 of ringing key K3 are opened. At this point, capacitor C39 is connected to the circuit through large resistor R40 and the generator is producing a 930-cycle frequency. The internal generator is a tapped-coil (Hartley) oscillator with grounded plate. Serving as the plate of the internal oscillator is the screen grid of tube J3 which is a-c coupled with the lower point of internal circuit 11 (ground) through high-value capacitor C42. The bias on the control grid of the tube is derived from the tube's cathode current which flows through resistor R11 (Fig. 60).

Transformer Tp9 is connected to the plate circuit of tube J3 as a load. Primary winding 1-2 of this transformer together with capacitor C43 forms an oscillatory circuit tuned to frequencies of 800-930 cycles. The ringing signal (test level) for both telephone channels is tapped from secondary winding 5-6 of transformer Tp9, which is connected to the proper channel only when a call is sent. The output level of the ringing generator, when the latter is used as a 930-cycle test generator (service call frequency), is checked by means of indicator device ИП . This indicator is connected (through contacts 1-4 of switch B8 and potentiometer R38) to germanium diode $\Delta 8$. Voltage from secondary winding 3-4 of transformer Tp9 reaches this diode through potentiometer R38 and resistor R39. Potentiometer R38 is used for factory calibration of the indicator readings, while the level of the output voltage of the generator is adjusted by means of potentiometer R37 which is connected to the plate-screen circuit of generator tube J3 . The shaft of this potentiometer is remoted to the front panel of the section underneath the slot (Fig. 51, No. 12).

Proper operating condition of tube J3 of the ringing generator is checked by means of indicator device ИП which is connected through contacts 1-9 of switch B8 to small resistor R42 coupled to the cathode circuit of the tube.

C41 is a blocking capacitor.

Low-Frequency Filters

The low-frequency filters ($\phi\text{H}\gamma$) of the first telephone channel, connected in its transmitting and receiving branches, are identical in terms of their circuitry and electrical characteristics (Fig. 61). The inductance coils of the filters are manufactured of Alsifer rings type TKCh-55. The filter capacitors are of mica, type SSG (Fig. 61).

The filters are hermetically sealed. The rated value of the characteristic impedance of the filters is 600 ohms.

The passband of the low-frequency filters is designed to pass a frequency spectrum of 300-2700 cycles. The attenuation introduced by the filters within the greater part of the passband is about 0.25 nepers. The attenuation characteristics of the low-frequency filters for the first telephone channel are given in Fig. 62. The attenuation introduced by the filters on the frequencies of the other channels of the station is not less than 4.5 nepers.

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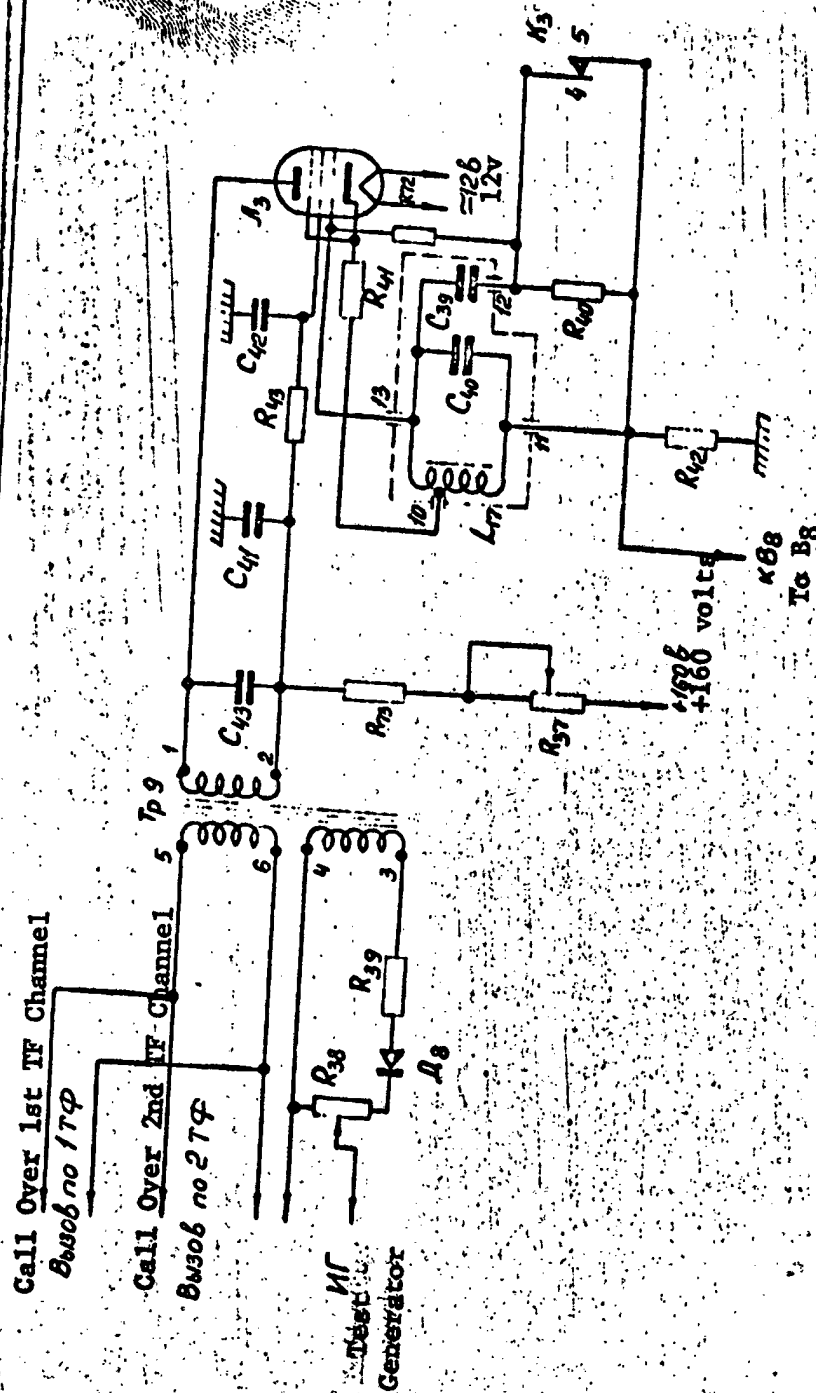


Рис. 60 Схема генератора тонального вызова.
Fig. 60 Diagram of Ringing Generator

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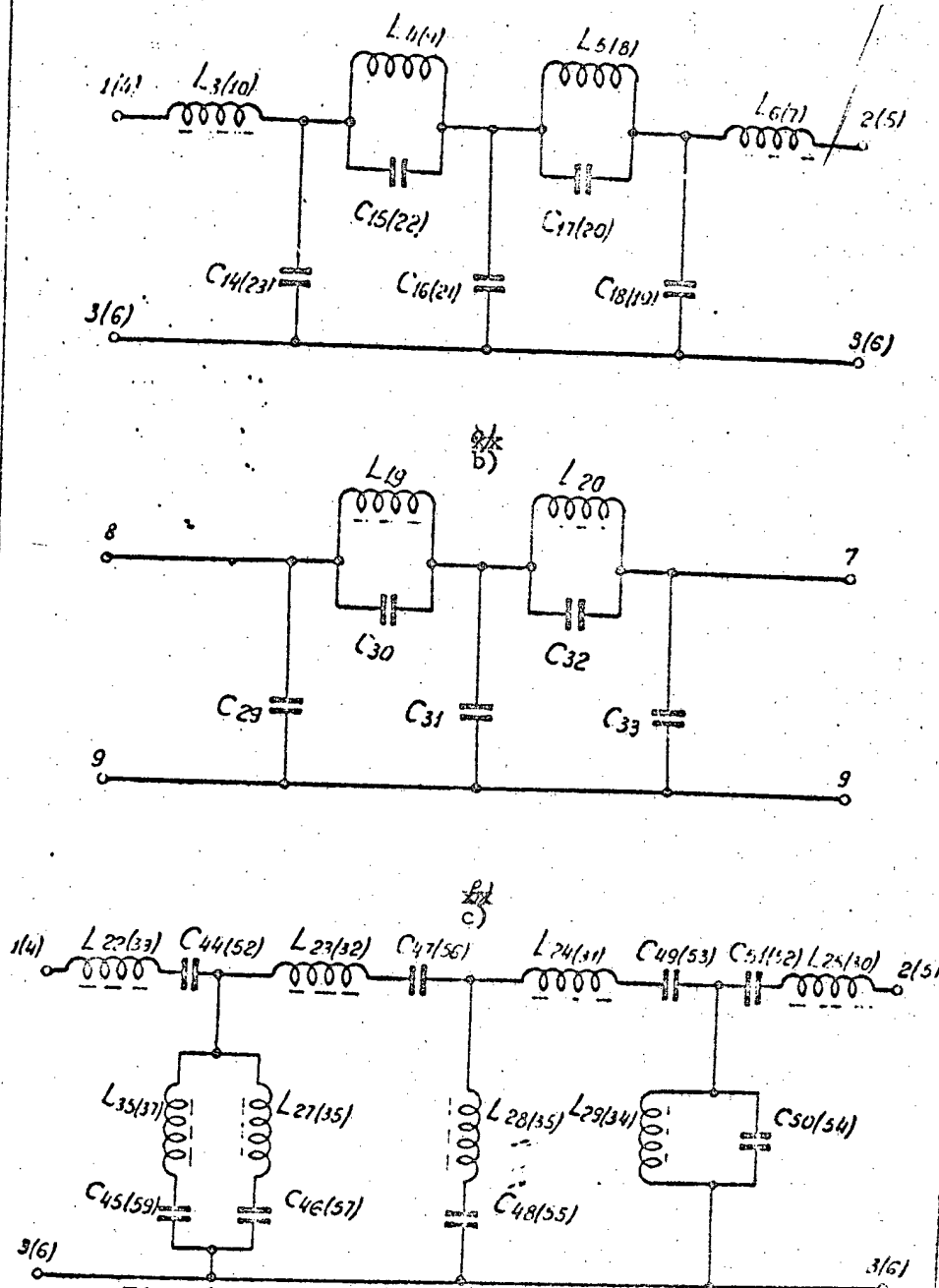


Fig. 61 Diagrams of Filters of First and Second Channels

Рис. 61 Схемы фильтров 1^{го} и 2^{го} каналов

- а) Фильтр низкой частоты ФНЧ-1. а) LF Filter #1
 б) Фильтр низкой частоты ФНЧ-2. б) LF Filter #2
 в) Фильтр полосовый ПЧ. в) Band Filter

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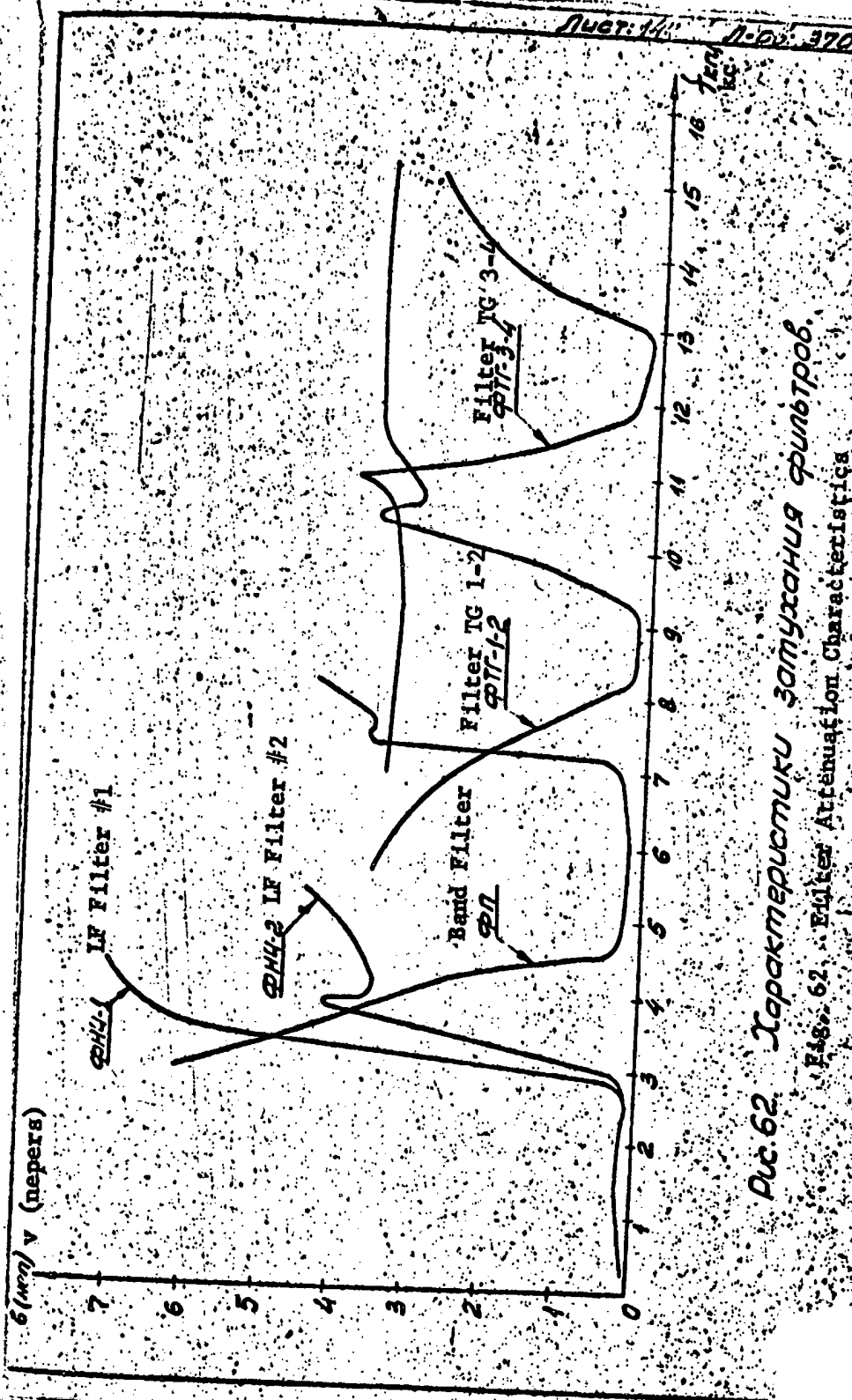


Рис. 62. Характеристики затухания фильтров.

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Second Telephone Channel

The second telephone channel of the station is a supersonic channel. Basic to its operation is the principle of high (supersonic) frequency telephony without transmission of the carrier. The 300-2700 cycle speech frequencies transmitted over the second telephone channel are converted into higher (supersonic) frequencies of 4700-7100 cycles, which are then transmitted over the radio channel.

The process of converting the speech frequency spectrum into another frequency region in the transmitting branch of the channel is called modulation, and the element in which this conversion takes place is called the modulator.

Fig. 64 shows a block diagram of the telephone channel, beginning with the amplitude limiter output in the transmitting branch and extending to the low-frequency amplifier input in the receiving branch. Basically, the diagram of the second telephone channel is similar to that of the first (Fig. 53). For this reason, the passage of a signal and of ringing in the various operational modes of the second telephone channel from the subscriber (switchboard) to the output of the limiter and from the input of the low-frequency amplifier to the subscriber (switchboard) can be easily understood from the description of the corresponding operational modes for the first telephone channel (see above) (Fig. 64).

The signals transmitted over the second telephone channel pass from the output of the amplitude limiter (contacts 3c-9B of adapter Π K9) through pad Y11 (with an attenuation of 0.5 nepers) to the input of modulator M. Fig. 65a shows an approximate frequency spectrum of a speech signal transmitted over the second telephone channel. There takes place in modulator M, which is a nonlinear element, the amplitude modulation of the oscillations of oscillator Γ , operating on a frequency of $f_H = 7.4$ kc, by the spectrum of the speech signal. The spectrum of the amplitude-modulated signal will contain the subcarrier frequency f_H and the two side spectra (Fig. 65b).

The upper sideband lies within 7,700-10,100 cycles (from $f_H + 300$ to $f_H + 2700$), while the lower sideband lies within 4,700-7,100 cycles (from $f_H - 2700$ to $f_H + 300$). (Figs. 65 and 66). The frequency relation of the amplitude of the oscillation components in the lower sideband is of an inverse character with respect to the frequency of the transmitted signal (Fig. 65a). The amplitude-modulated oscillations travel from the output of modulator M through pad Y12 (with an attenuation of 0.5 nepers) and reach the input of band filter $\Pi\Phi$ which has a passband of 4.7-7.1 kc. At the output of this filter the subcarrier frequency ($f_H = 7.4$ kc) and the upper sideband are greatly attenuated, while the discriminated lower sideband is fed to the input of the modulation amplifier of the transmitter (contacts 5c-6c of adapter Π K1).

From the output of the receiver (contacts 9B-0B of adapter K1) the received signals, passing through pad Y15 (with an attenuation of 0.5 nepers) and the contacts of the station operation mode switch B4, reach the input of band filter $\Pi\Phi$. Of the entire spectrum of received frequencies this filter passes only those which correspond to the lower sideband of frequencies transmitted over the second telephone channel (4.7-7.1 kc). The signal, after it has passed through the band filter, further travels through pad Y14 (with an attenuation of 0.5 nepers) to the input of demodulator Δ . The demodulator is a nonlinear element. When the demodulator is acted upon by the oscillations of the received lower sideband and

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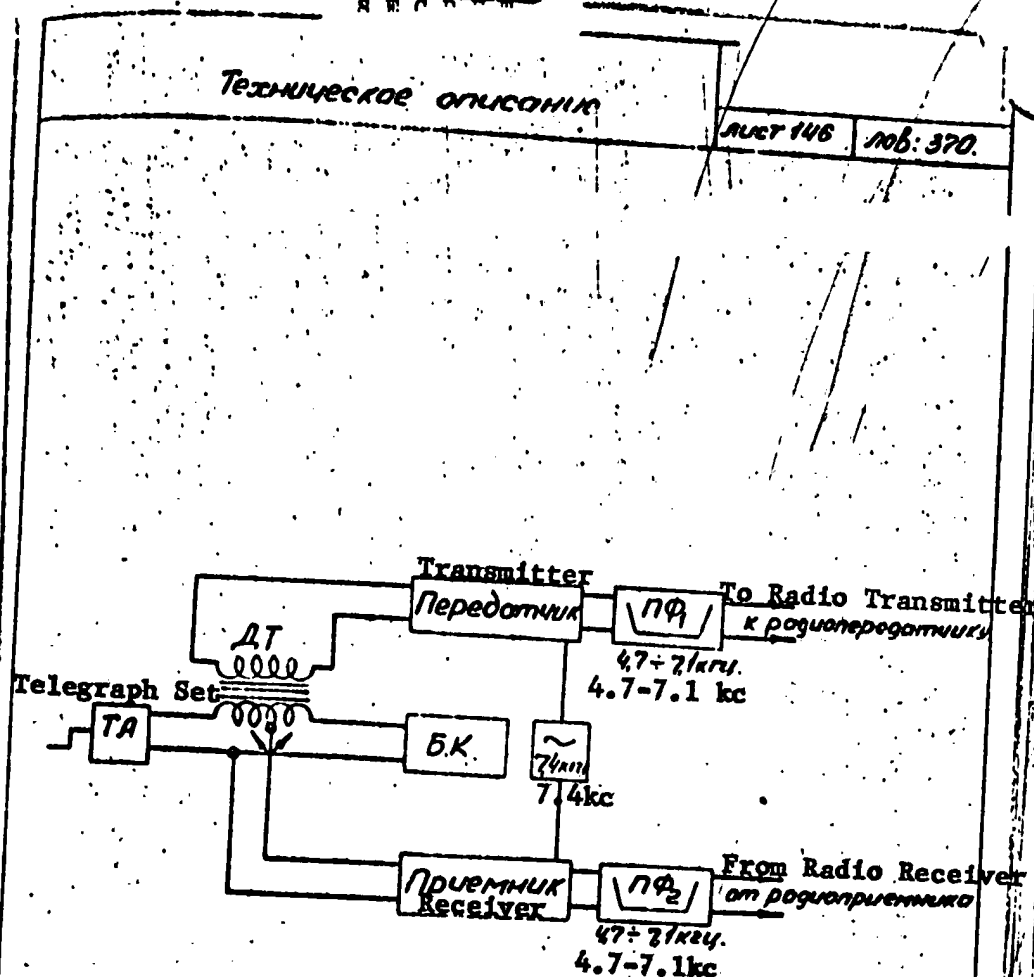


Рис. 63 Упрощенная блок-схема второго телефонного канала.

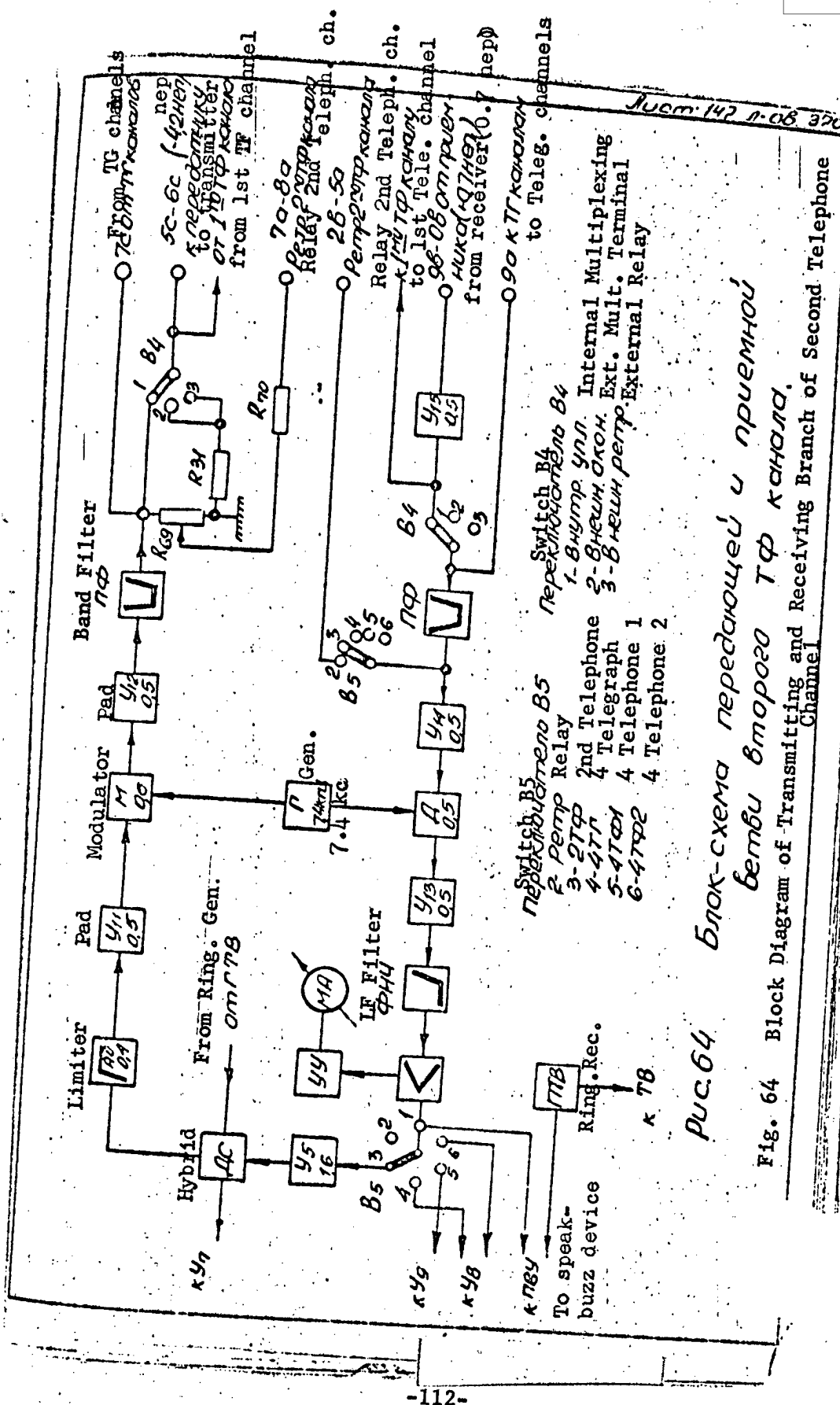
Fig. 63 Simplified Block Diagram of Second Telephone Channel

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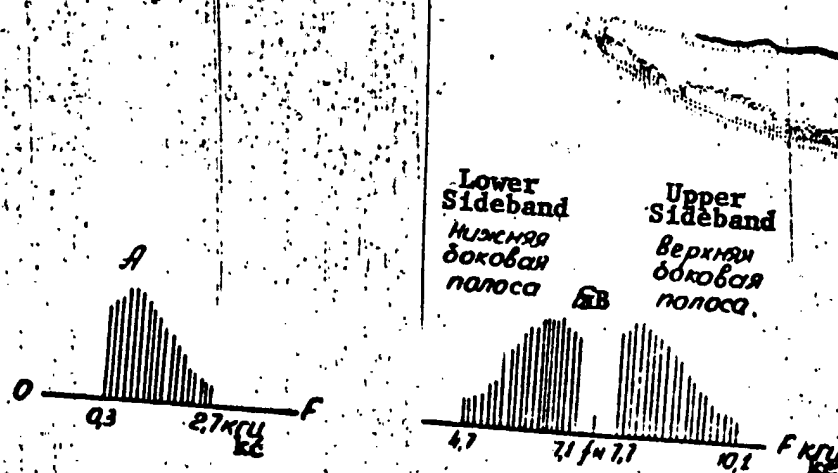


Рис. 65.

Fig. 65 Frequency Spectrum Conversion

Преобразование спектра частот

А. Спектр частот разговорного сигнала

Б. Преобразованный спектр частот

A) frequency spectrum of speech signal

B) converted frequency spectrum

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those of subcarrier oscillator ($f_H = 7.4$ kc), there appear on its output, in addition to these frequencies (Fig. 66), their harmonics ($2f$ and $2f_H$) and combination components ($f_H + f$ and $f_H - f$). From the output of demodulator Δ the signals pass through pad Y13 (with an attenuation of 0.5 nepers) to the input of low-frequency filter $\Phi H \gamma$ of the second telephone channel. This filter passes only the difference combination components 0.3-2.7 kc. From the output of the filter the signal, traveling through pad Y (consisting of resistors R34-R35-R36), reaches the input of the low-frequency amplifier (contacts 2B-2c of adapter K9). Subsequently, the signal travels to the subscriber in the same way as in the first telephone channel (Fig. 53).

Operational and service calls (test level) are transmitted over the second telephone channel from the common ringing generator (see above) on the same frequencies as employed over the first telephone channel (800 and 930 kc, respectively). These frequencies are converted in modulator M into ringing frequencies of 6.6 kc (operational call) and 6.47 kc (service call) which are then sent out over the radio channel. In reception, the 6.6 and 6.47-kc frequencies are converted in demodulator Δ to frequencies of 800 and 930 kc, respectively, which act on the voice-frequency ringing receiver of the second telephone channel in the same manner as in the first telephone channel (see above).

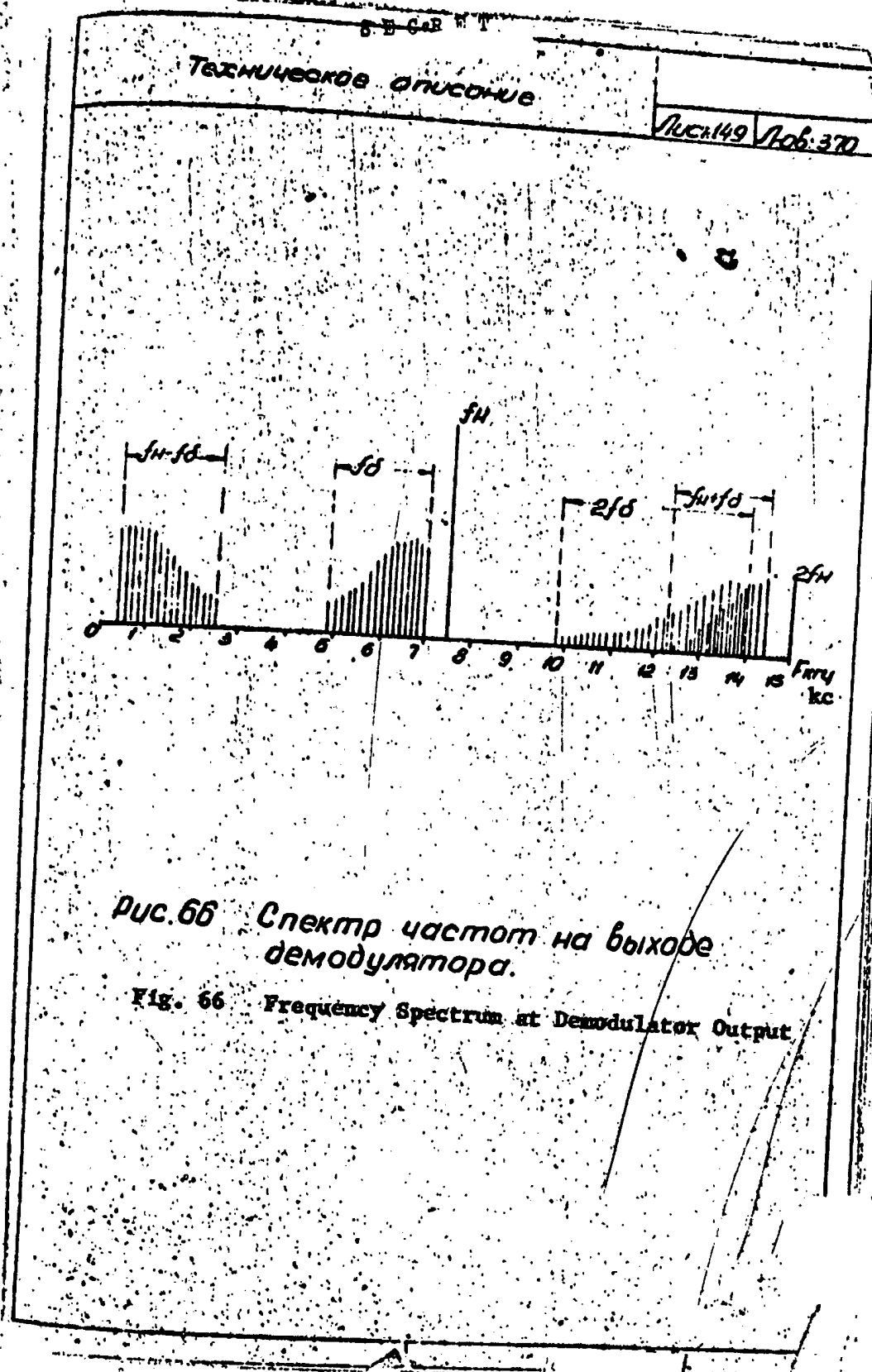
With relay of the signals over the second telephone channel, operation mode switch B5 is set in position 1 (PETP - "RELAY"). In this case, the signals received by the radio receiver of the particular half-set travel from contacts 9B-0B of adapter $\Pi K1$ through pad Y15, the contacts of switch B4, band filter $\Pi \Phi$ and the contacts of switch B5 to the transmission branch of the second telephone channel of the other half-set (contacts 2B-5a of adapter $\Pi K2$).

In order to provide the possibility of calling an intermediate station over the second telephone channel, the receiving branch of that channel, together with the ringing receiver, remains connected to the output of band filter $\Pi \Phi$. The signals received by the radio receiver of the other half-set reach the telephone channel section over contacts 8a-7a of adapter $\Pi K2$. From these contacts the signal passes across resistor P70 and potentiometer R60 through the contacts of switch B4 and contacts 5c-6c of adapter $\Pi K1$ to the input of the transmitter modulation amplifier. In this fashion, the signals of the second telephone channel are relayed on supersonic frequencies 4.7-7.1 kc (not converted to a lower frequency) and only one band filter connected in the receiving branch of the channel is involved in the relay.

When the station is operating with external multiplexing equipment the second telephone channel is disconnected, by means of station operation mode switch B4, both from the transmitting as well as from the receiving branch of the radio channel.

The differential system (hybrid), amplitude limiter, low-frequency amplifier with level indicator, voice-frequency ringing receiver and magneto ringing receiver in the second telephone channel are similar in their circuitry, operational principle and electrical characteristics to the corresponding equipment of the first telephone channel. The pole changer and ringing generator are shared by both telephone channels; i.e., they are "common" units. These components have been described above. A description is given below of the other elements of the second telephone channel.

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Modulator

Design-wise, the modulator is located in the frequency conversion unit and employs a ring-type balancing network (Figs. 67-68), consisting of two transformers Tpl0 and Tpl1 and germanium diodes 49. The germanium diode bridge constitutes a nonlinear element. The diodes are connected in the circuit in the manner of a "ring", whence the modulator circuit has received the name "ring circuit" (Figs. 67 and 68).

The principal of frequency conversion in the ring-type modulator consists in the following: there is fed to winding 1-2 of input transformer Tpl0 an 0.3-2.7 kc low-frequency voltage, while to the midpoints of windings 3-6 of transformers Tpl0-Tpl1 a voltage with a frequency of 7.4 kc is fed from generator f (Fig. 57).

It is well known that the impedance of diodes in the forward direction is small, although in the reverse direction it is quite large.

The voltage of the 7.4-kc generator alternately changes the conductance of the modulator diodes so that in the positive half-period of the oscillator voltage the diodes of the longitudinal branches possess the greater conductivity (Fig. 68a) and in the negative half-period - the diodes of the transverse branches (Fig. 68b).

Consequently, the current of the audio frequency to be converted in the primary winding of output transformer Tpl1 (and consequently, in the secondary as well) and in load PH flows in one direction during the positive half-period of the frequency of oscillator f and in the reverse direction during the negative half-period.

Thus, the action of the ring-type modulator resembles that of a current reverser with a switching frequency of 7.4 kc, and the current wave form at the output of the modulator will appear as shown in Fig. 69. From this figure it is clear that the current at the output changes with a frequency of 7.4 kc, while its amplitude varies according to the law governing the change of the audio-frequency voltage reaching the modulator input (Fig. 69).

Consequently, there are received at the output of the modulator amplitude-modulated oscillations, the frequency spectrum of which is illustrated in Fig. 65b. The oscillations pass from the modulator output through pad T12 to the input of band filter $\Pi\phi$ (Fig. 64). At the output of this filter there are separated the oscillations only of the lower sideband of the frequencies, which then reach the input of the transmitter modulation amplifier.

In order to achieve complete circuit symmetry for the balancing modulator, at which the unnecessary 7.4-kc voltage will be absent at its output, variable resistors R45 and R46 (which are called "balancing" resistors) are employed in the modulator.

The attenuation introduced by the modulator in the frequency conversion of the transmitted signal is approximately 0.6 nepers.

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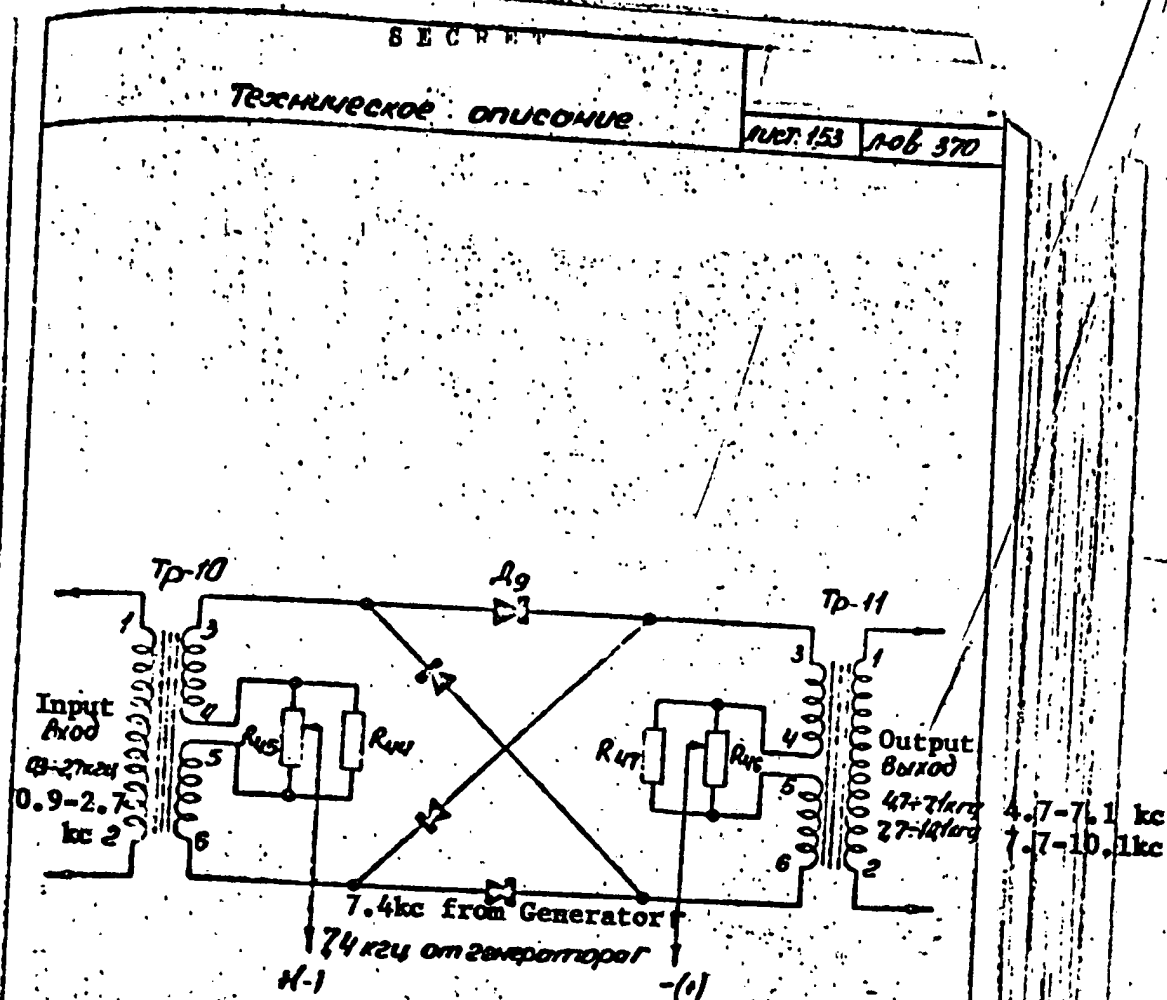


Рис. 67 Схема модулятора.

Fig. 67 Modulator Diagram

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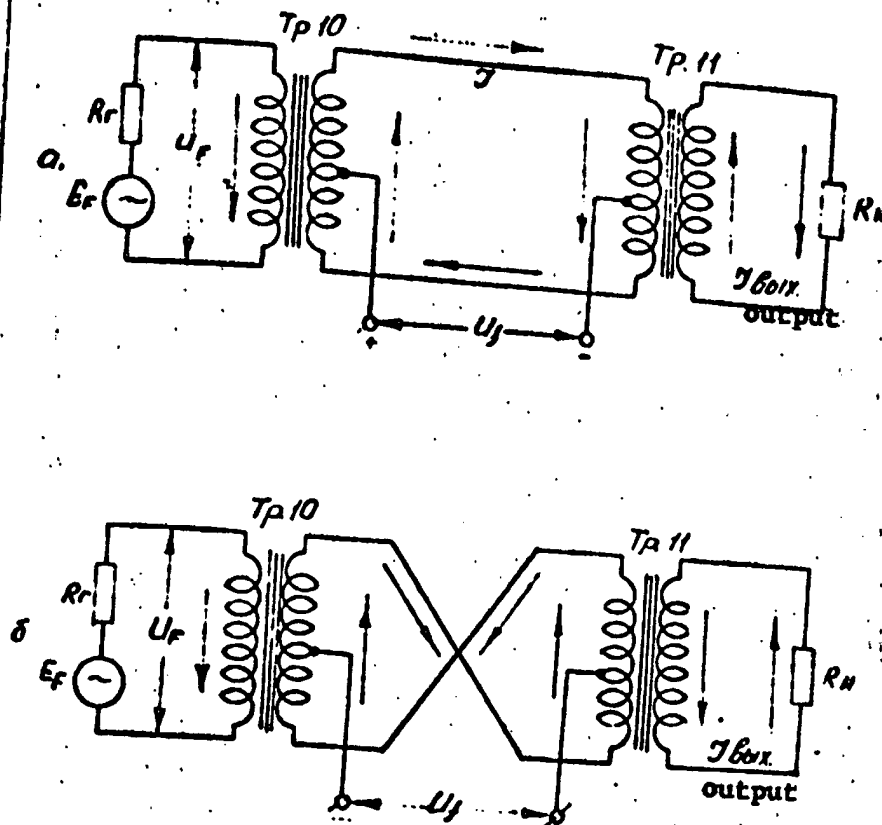
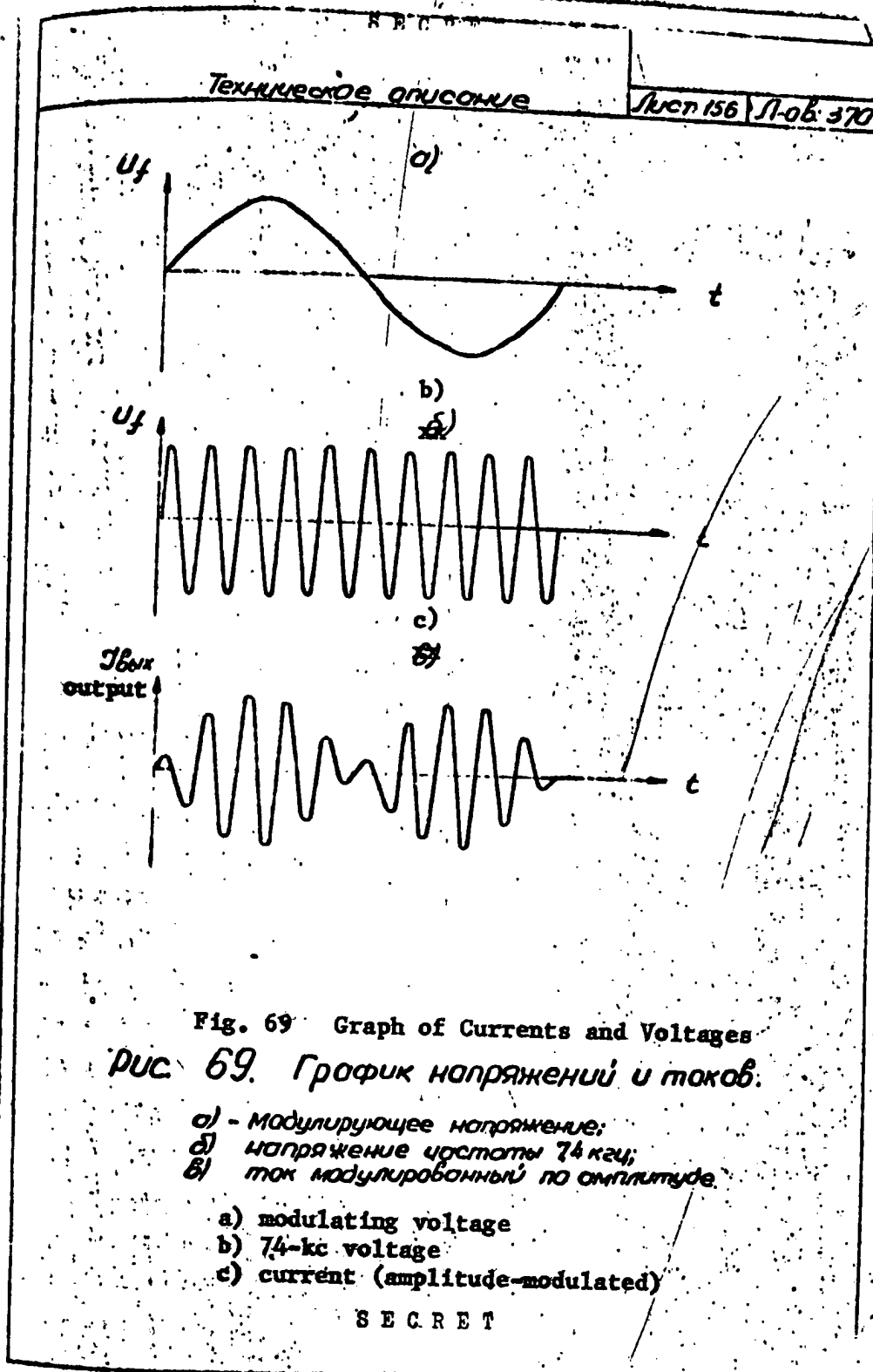


Рис. 68

Схемы, поясняющие принцип работы
кольцевого модулятора

Fig. 68 Diagrams Illustrating the Operational
Principle of the Ring Modulator

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Demodulator

Design-wise, the demodulator is located in the frequency conversion unit and employs a ring-type balancing network consisting of two transformers Tpl2 and Tpl3 and germanium diodes $\Delta 10$. The circuitry and operational principle of the demodulator are similar to the circuitry and operational principle of the modulator. The 4.7-7.1 kc oscillations received by the radio receiver and separated by band filter $\Pi\Phi$ reach the nonlinear bridge through pad Y14 and transformer Tpl3. The 7.4-kc voltage is fed to the nonlinear bridge through the mid-points of windings 3-6 of transformers Tpl2 and Tpl3.

At the output of the demodulator there are only the difference (0.3-2.7 kc) and the sum (12.1-14.5 kc) combined components. The difference combined components correspond to the signal transmitted over the second telephone channel. The oscillations with the converted frequency spectrum pass from the demodulator output through pad Y13 to the input of low-frequency filter $\Phi M1$ of the second telephone channel. This filter passes only the low-frequency oscillations (0.3-2.7 kc) and holds back all the supersonic frequencies. From the output of the low-frequency filter the low (audio) frequency oscillations reach the input of the low-frequency amplifier ($M2$) of the second telephone channel. Because of the presence in the receiving branch of the second telephone channel of a low-frequency filter, the requirements for demodulator balancing are somewhat relaxed, and for this reason, there are no balancing resistors in the demodulator.

The attenuation introduced by the demodulator in the conversion of the frequencies of the received signal stands at approximately 0.5 nepers.

Oscillator

Design-wise, the 7.4-kc frequency oscillator is located in the converter unit and is a single unit common to the modulator and demodulator of the second telephone channel. The oscillator uses a type 12Zh1L tube ($M4$) with a double-circuit electron-coupled arrangement (Fig. 70). The oscillator is characterized by high frequency stability permitting normal operation of the second telephone channel without the need for frequency synchronization of the oscillators of corresponding stations. The frequency of the generated 7.4-kc oscillations is determined by the internal hermetically sealed circuit L18-C34. The internal oscillator is a tapped-coil (Hartley) oscillator with grounded plate. Serving as the plate of the internal oscillator is the screen grid of tube $M4$ which is a-c connected with the lower point of circuit 2 (ground) by means of high capacitor C36. The bias on the control grid of the tube is derived from the grid current flowing through resistor R49. This resistor is blocked against alternating current by capacitor C35.

Connected, as a load, in the plate circuit of the tube is hermetically sealed oscillatory circuit L21-C39, tuned to a frequency of 7.4 kc. This circuit is inductively coupled to the modulator (winding 4-5) and the demodulator (winding 6-7).

Proper operating condition of tube $M4$ is checked by means of indicator device $M1$ which is connected through contacts 1-8 of switch B8 to low resistor R48 coupled to the cathode circuit of the tube. C37 is a blocking capacitor.

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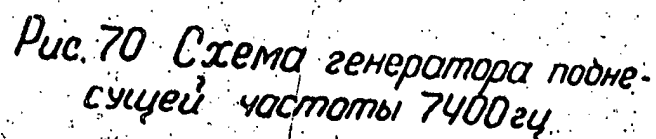


Fig. 79 Diagram of 7400-cycle Subcarrier Generator

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Filters

The band filters $\Pi\Phi$ of the second telephone channel, present in its transmitting and receiving branches, are identical in their circuitry and electrical characteristics (Fig. 61). They are designed to pass a frequency band of 4700-7100 cycles. The attenuation introduced by the filters in the greater region of the passband is approximately 0.34 nepers. On the frequencies of the other channels of the station the filters provide an attenuation of not less than 3.5 nepers. The attenuation characteristics of the second telephone channel band filters are shown in Fig. 62. The low-frequency filter $\Phi\Pi\Pi$, connected in the receiving branch of the second telephone channel, has a simpler circuit than the low-frequency filters of the first telephone channel (Fig. 61) and is designed to pass frequencies up to 2700 cycles.

The attenuation introduced by the filter over the passband is about 0.12 nepers, while for the supersonic frequencies, filter attenuation is not less than 3.5 nepers. Fig. 62 shows the attenuation characteristic of the low-frequency filter of the second telephone channel.

The inductance coils of all the filters for the second telephone channel are designed to use Alsifer rings type TChK-55. Mica capacitors type SSG are used in the filter, which are hermetically sealed. The rated characteristic impedance of the filters is 600 ohms.

External Multiplexing Channel

When the station is to operate in terminal mode with external multiplexing equipment, the station operating mode switch B4 (Fig. 58) is set in position 2 (BHEW H. OKOH - "EXTERNAL TERMINAL"). The external multiplexing equipment is connected over a four-wire circuit to the line board of the station. The signals transmitted from the external multiplexing equipment reach the telephone channel section over contacts 5B-6B of adapter Π K1. From these contacts, passing over station operating mode switch B4, pad Y (consisting of resistors R27-R28-R30) and broadband transformer Tp5, they reach the input of the modulation amplifier of the transmitter (contacts 5c-6c of adapter Π K1). The signals, picked up by the radio receiver, are fed to the telephone channel section over contacts 8a-9c and further, through switch B4 and contacts 3B-4B of adapter Π K1, they reach the line board (not shown in Fig. 53).

When the signals of the external multiplexing equipment are relayed at the intermediate station, the operating mode switch B4 is set at position 3 (BHEW H. PETP - "EXTERNAL RELAY"). In this case, the signals, received by the half-set radio receiver are fed from contacts 8a-9c through switch B4 to contacts 1a-2a of adapter Π K2, from which they enter the telephone channel section of the other half-set over contacts 3a-4a of adapter Π K2. From these contacts the signals travel over switch B4, pad Y and transformer Tp5 to the modulation amplifier input (contacts 5c-6c of adapter Π K1).

With the station operating with external multiplexing equipment, the possibility of operating over the first telephone channel is maintained, both in the terminal as well as in the relay mode. The transmitting branch of the channel remains connected to the transmitter modulation amplifier input, and the receiving branch - to the receiver output. The second telephone channel and both telegraph channels are disconnected, by means of station operating mode switch B4, both from the transmitting and receiving branches of the radio channel when the

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station is operating with external multiplexing equipment. In this case, the transmitting branch of the first telephone channel is terminated in resistor R31 by means of switch B4.

When the station is operating with its own multiplexing equipment, with the station operating mode switch B4 set at position 1 (BHYTP. YHJ. - "INTERNAL MULTIPLEXING"), the output of the radio receiver for the external multiplexing channel is terminated in a 620-ohm resistance (R62) through contacts 8a-9c and switch B4.

Speak-Buzz Unit

The speak-buzz unit ПБУ provides for service (operator's) communication between the stations of the radio link and with the switchboards of the terminal stations over any telephone channel, as well as making possible the adjustment of rated levels in those channels and the monitoring of traffic over them. The speak-buzz unit also permits single channel working with increased frequency deviation.

The circuit of the speak-buzz unit contains the following elements: speech keys K1 and K4 (each channel has its own key), monitoring key K2, ringing key K3, autotransformer Tp7, operator's set T-Nk and other minor components (capacitors and resistors).

When the speak-buzz unit is connected in the direction of the radio link, speech key K1 (K4) is set in position P.KAH ("RADIO CHANNEL"). The microtelephone handset is connected to the radio channel over a four-wire circuit: earphones T are connected to the output of the proper low-frequency amplifier through resistor R10 and contacts 29-30, 11-12 and 14-15 of speech key K1 (K4), while microphone Mk is connected to the input of the differential system (hybrid) of the proper channel through autotransformer Tp7, capacitors C60, C78 and C79 and contacts 8-9 and 23-24 of speech key K1 (K4). In this case, when a call is received from the switchboard, the light goes on in green signal lamp JH1 (JH2) and the bell rings, but the call does not travel further in the direction of the radio line, since contacts 25-26 of the speech key break the feed circuit of relay P2 (P9). In order to send an operational call toward the radio line, key K3 is placed in position B43 ("CALL"). The voltage (+12 volts) is fed to relay P2 (P9) through contacts 8-7 of key K3 and contacts 27-26 of speech key K1 (K4). This relay operates and an 800-cycle signal is sent to the transmitting branch of the proper channel. In order to call a station on the radio link and also to transmit a test level, key K3 is placed in position C1. B43 ("SERVICE CALL"). In this instance, the voltage (+12 volts) is fed to the same relay P2 (P9) through contacts 12-11 of this key and 26-27 of the speech key. However, in this case, because of the breaking of contacts 4-5 of key K3, a 930-cycle signal will be sent to the transmitting branch of the corresponding channel.

In order to speak, the button of the operator's set is pressed. This makes the microphone circuit: contact 3 of the terminal block of the operator's set - microphone Mk - button contacts - contact 4 of the terminal block of the operator's set - part of winding AT of autotransformer Tp7 - ground resistance R58 - contact 3 of the operator's set block. The microphone is fed from voltage divider R59-R58.

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With the speak-buzz unit connected in the direction of a switchboard, speech key K1 (K4) is placed in position KOM ("SWITCHBOARD"). Now the operator's set is connected through contacts 4-5 and 19-20 of speech key K1 (K4) to the proper wire line over a two-wire circuit similar to that of field telephone TAI-43. In this event, because of the breaking of contacts 17-18 of key K1 (K4), relay P3 is disconnected from the left-hand contact of polarized relay P5 (P12). Relay P4 (P11) is connected to the left-hand contact of relay P5 (P12) through contacts 1-2 of speech key K1 (K4).

This provides for reception at the station of both service and operational calls. When a call is received at the station, a light flashes in the corresponding red signal lamp JH2 (JH4) and the bell rings. In order to send a call to a switchboard, the ringing key may be set in either position B#3 or C#3 ("CALL" or "SERVICE CALL"). The voltage (+12 volts) is fed to relay P3 (P10) through contacts 8-7 or 12-11 of key K3 and contacts 16-17 of speech key K1 (K4). When this relay operates, pole changer TB is fed and its output is connected to the proper wire line into which the magneto ringing is being sent. The button of the micro-telephone must be pressed. The microphone circuit is formed in the same fashion as when speaking over the radio link.

The establishment of the feed circuits of the microphone and corresponding relays is accomplished in such fashion that the speak-buzz unit makes it possible to call a switchboard, conduct conversation with it and to receive a call from the switchboard with the transmitter and receiver of the switchboard disconnected. For this purpose, when battery power supply is being used, one of the storage battery groups must be set for discharge on the charging board, while in the case of a-c mains feeding it must be connected on the mains board.

When operating in the relay mode, in order to talk from the station the speak-buzz unit is connected to the proper channel in the required direction (half-set) by means of speech key K1 (K4). The call is sent and a conversation conducted in the manner described above.

Traffic over the telephone channels is monitored at the terminal station by means of monitoring key K2. In this case, earphones T of the operator's set are connected to the channel through autotransformer Tp7, contacts 29-28 of keys K1 and K4, capacitor C78, resistor R57 and the proper contacts of monitoring key K2.

Telephone channel communication may be monitored at an intermediate station both by means of monitoring key K2 and speech key K1 (K4), with the latter set in position P.KAH ("RADIO CHANNEL"). In the last case, earphones T of the operator's set are connected to the low-frequency amplifier output of the proper channel, as explained above.

Single-Channel Operational Mode

In order to place the station on the single-channel operational mode, speech key K1 of the first telephone channel is placed in position P.KAH ("RADIO CHANNEL") and switch B9 in position OAHOK ("SINGLE-CHANNEL"). The operator's set T-Mk is connected to the radio channel over a four-wire system, as described above. Contacts 1-3 of switch B9 short resistors R23 and R26 in pad Y located in the transmitting branch of the first telephone channel (Fig. 53). This increases the level of the modulating voltage and, consequently, the frequency deviation of the transmitter. At the same time, through contacts 2-4 of switch B9, resistor R63 and

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contact 7a of adapter Π K1 of the telephone channel sections, a voltage (160 volts) is fed to relay P1 in the transceiver section (Fig. 71). Relay P1 operates and the plate voltage is disconnected from the transmitter while the feed element is terminated in load resistance R10 in the plate circuit. Thus, with the button of the operator's set released, the station is operating only on reception (the plate voltage has been taken from the transmitter). For transmission operation the button of the set must be depressed, in which case the winding of relay P1 is shunted by the low resistance of the part of the winding TA of autotransformer Tp7 through contact 4, the contacts of the button and contact 1 of the set terminal plate. Relay P1 lowers its armature and the plate voltage is fed through its contacts 1-1₂ to the transmitter. Meanwhile, the microphone circuit is made in the manner described above (Fig. 71).

7.

Telegraph Channel Section

Mounted in the telegraph channel section are those circuit elements which pertain to the first and second telegraph channels of the station, in addition to the noise-suppression filters. These elements are described below. Charts indicating the constant voltages and resistances of the telegraph channel section are given in Appendix 3. A basic diagram of the telegraph channel section will be found in Vol. 2.

Design of the Section

The basic feature in the design of the telegraph channel section is the cast Silumin mounting rack to which are fastened, by means of screws, the cast Silumin front panel and individual components of the section. An external view of the telegraph channel section is given in Figs. 72 and 73.

The individual components are electrically coupled with the circuit of the section by means of connecting adapters. The most important circuit elements (filters, oscillator and discriminator circuits, etc.) are enclosed in hermetically sealed shields.

The telegraph channel section design permits replacement of all tubes from the left- and right-hand sides of the section. The casing of the section consists of light sheet duraluminum and has in its rear panel apertures through which a knife-shaped connecting adapter and guide bushings may be passed.

The telegraph channel section in its casing measures 165 X 380 X 425 mm and weighs 17 kg.

Circuitry of the Section

The telegraph channels of the station are supersonic, their operation being based on the principle of frequency-modulated telegraphy. Each telegraph channel consists of transmitting and receiving equipment and a line unit. The block diagrams (Figs. 74 and 75) and the basic circuitry of both telegraph channels are identical.

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рис. 71 Одноканальная работа.
To K1 (K4) Fig. 71 Single Channel Operation

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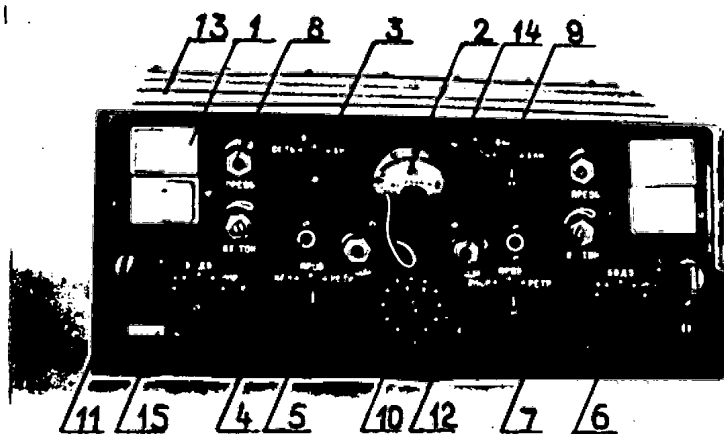
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FIG. 72 - Telegraph Channel Section

1. Transmitting and Receiving Relays Type PП-4 (P_1, P_2, P_3, P_4)
2. Indicator Device
3. Telegraph Channel Power Selection Switches (B_5, B_6)
4. Channel Check-Out Jacks (r_1, r_2)
5. Channel Operating Mode Switches (B_1, B_3)
6. Channel Operation Selecting Switches (B_2, B_4)
7. Input Current Adjusting Potentiometers (R_{22}, R_{54})
8. Bias Adjusting Potentiometers (R_6, R_{39})
9. Magnetizing Current Adjusting Potentiometers (R_{26}, R_{58})
10. Indicator Switch (B_7)
11. Catch for Fastening Section to Case
12. Forward Panel
13. Case
14. Fuse
15. Identification Shield

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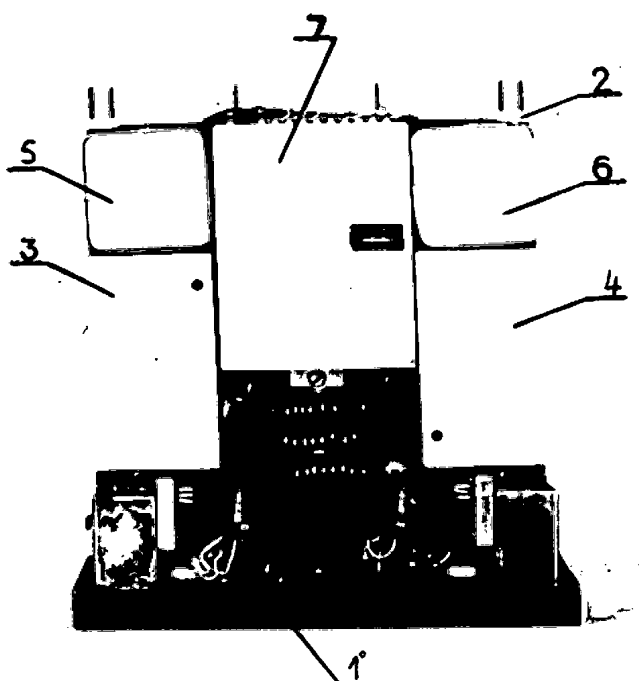
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FIG. 73 - Upper View of Telegraph Channel Section
with Case Removed

1. Forward Panel
2. Frame
3. First Telegraph Channel Element
4. Second Telegraph Channel Element
5. First Telegraph Channel Filters
6. Second Telegraph Channel Filters
7. Line Circuit Feed Element

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The line circuit feed converter consists of a single element common to both telegraph channels (Figs. 74 and 75).

Fig. 74 shows the block diagram of the transmitting branch of the telegraph channels. Current pulses of different polarity (when working with P-100 telegraph sets) or current and no-current pulses (when working with ST-35 telegraph equipment) travel from the transmitting set through the line board (not shown in Fig. 74) and reach contacts 3a-4B (7a-5B) of adapter ПК1. Subsequently, the telegraph pulses reach the windings of polarized relay P2 (P4), passing through duct capacitors C51-C59 (of the noise-suppression filter), potentiometer R22 (R54), resistor R21 (R53), and resistor R19 (R51) or R20 (R52) (depending upon the mode of operation and the polarity of transmission). Potentiometer R22 (R54), the shaft of which has been remoted to the front panel of the section underneath the slot (Fig. 72, No. 7), is used to adjust the input current (50 ma for the ST-35 equipment and 25 ma for the P-100 equipment). The value of this current is monitored by means of indicator device ИИ which is connected to resistor R21 (R53) through contacts 1-4 (1-10) of switch B7 (Fig. 72, Nos. 2 and 10). The armature of polarized relay P2 (P4) controls the frequency of the oscillations of oscillator Г. To the positive pulses (when working with the P-100 set) or current (marking) pulses (when working with the ST-35 set) correspond oscillations with a frequency of 9.1 (12.8) kc, while to the negative or no-current (spacing) pulses there correspond oscillations with a frequency of 8.5 (12.2) kc. The frequency of the oscillator, at the moment the armature of transmitting relay P2 (P4) travels from one contact to the other, equals the mean frequency of 8.8 (12.5) kc. Consequently, when transmitting positive (marking) pulses, the frequency of the generator increases by $\Delta f_m = 300$ kc, and when transmitting negative (spacing) pulses decreases by the same value with respect to the mean frequency. The value Δf_m is referred to as the deviation (shift) of the oscillator frequency from its mean value.

In this fashion, the d-c telegraph pulses are converted into frequency-modulated supersonic oscillations. Since the frequency deviation always remains constant, the necessary band width for passing the frequency-modulated supersonic oscillations is determined by the maximum speed of telegraphy which, in the case of the telegraph channels of this station, equals 70 bauds. In this connection, the frequency band occupied by each telegraphy channel is approximately 800 kc. From the output of oscillator Г the frequency-modulated oscillations pass through pad Y, consisting of resistor R14 (R47) and potentiometer R13 (R46), the contact of switch B1 (B3), band filter ФТГ-2 (ФТГ-4) with a passband of 8.4-9.2 (12.1-12.9) kc and the contacts of switch B1 (B3), reaching the contacts 3c-4c of adapter ПК1. From these contacts the frequency-modulated signals from both telegraph channels pass through the telephone channel section (Figs. 63-64) to the input of the transmitter modulation amplifier.

When making an "against itself" (back-to-back) check of the operation of a telegraph channel, switch B1 (B3) is placed in position ПРОВ. ("CHECK") (position 2 in the block diagram of Figs. 74 and 75). In this case, the frequency-modulated oscillations are fed to the receiving branch of the same channel from the output of oscillator Г through the contacts of switch B1 (B3), band filter ФТГ-2 (ФТГ-4) and the contacts of switch B1 (B2).

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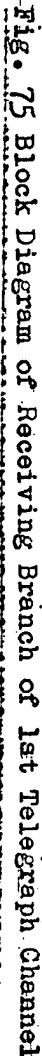


Fig. 75 Block Diagram of Receiving Branch of 1st Telegraph Channel

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When the telegraph channel signals are relayed at an intermediate station, switch B1 (B3) is placed in position PETP ("RELAY") (position 3 in the block diagram shown in Figs. 74 and 75). In this case, the received frequency-modulated signals pass from the output of the receiver of the first half-set through contacts 9B-0B of adapter NK1 of the telephone section, switch B4, contacts 9a-0B of adapter NK1 of the telephone section, contacts 9B-0B of adapter NK1 of the telegraph channel, switch B1 (B3), filter $\Phi T \Gamma - 1$ ($\Phi T \Gamma - 3$), contacts 1B-0B (9c-0B) of adapter NK1 of the telephone channel and relay cable $\mu - 4$, and reach contacts 2B-4c (7c-4c) of adapter NK1 of the telegraph section of the second half-set. From these contacts, the signals to be relayed pass through pad Y, consisting of resistors R10-R11 (R13-R44) and potentiometer R12 (R45), the contacts of switch B1 (B3), filter $\Phi T \Gamma - 2$ ($\Phi T \Gamma - 4$), the contacts of switch B1 (B2), contacts 3c-4c of adapter NK1 of the telegraph section, contacts 7c-6c of adapter NK1 of the telephone section, switch B4 and contacts 5c-6c of adapter NK1 of the telephone section to the input of the modulation amplifier of the transmitter of the same half-set.

A block diagram of the receiving branch of the telegraph channels is given in Fig. 75.

The supersonic telegraph signals travel from the output of the radio receiver through the telephone channel section to the telegraph channel section over contacts 9B-0B. Further, they pass through the contacts of switch B1 (B3), band filter $\Phi T \Gamma - 1$ ($\Phi T \Gamma - 3$) with a passband of 8.4-9.2 (12.1-12.9) kc, the contacts of switch B1 (B3) and reach the input of the amplifier tube $\Lambda 1$ ($\Lambda 3$). The tube of this amplifier simultaneously functions as an amplitude limiter which limits the spurious amplitude modulation of the received frequency-modulated telegraph signal fed to the frequency detector. Functioning as the frequency detector are oscillatory circuits L6-C9 and L7-C8 (L23-C33 and L22-C32) connected to the plate circuit of amplifier tube $\Lambda 1$ ($\Lambda 3$). By means of the frequency detector and the full-wave rectifiers using germanium diodes $\Delta 1 - \Delta 2$ and $\Delta 3 - \Delta 4$ ($\Delta 5 - \Delta 6$ and $\Delta 7 - \Delta 8$), the frequency-modulated supersonic telegraph signals are converted to d-c signals. These currents flow through the windings of polarized relay P1 (P3), the armature of which reproduces the telegraph operation by d-c signals. Potentiometer R6 (R39), the shaft of which is remoted to the front panel of the section under the slot (Fig. 72, No. 8), is used to adjust the bias in one of the windings of receiver relay P1 (P3). The presence of current in the winding of the receiver relay is checked by means of indicator device $\Pi \Pi$, which is connected to resistor R7 (R40) through contacts 1-6 (1-8) of switch B7 in position 1T Γ (2T Γ) (i.e., first or second telegraph channel). When working with P-100 equipment or in duplex working with ST-35 equipment (one set operating only in transmission and the other only in reception), the armature of receiving relay P1 (P3) is connected to contact 1a (5a) of adapter NK1 through noise-suppression filter L16-C22 (L32-C46), contacts 7-10 and 7-9 of switch B2 (B4), resistor R27 (R59), contacts 4-5 of jack $\Gamma 1$ ($\Gamma 2$), resistor R28 (R62) and duct capacitor C49 (C56). The receiving telegraph set is connected to contacts 1a-2a (5a-6a) of adapter NK1 through the line board (not shown in Fig. 75). The current going out to the receiving telegraph set is checked by means of indicator device $\Pi \Pi$ which is connected to resistor R27 (R59) through contacts 1-3 (1-11) of switch B7. Jack $\Gamma 1$ ($\Gamma 2$) is used for the connection of the telegraph channel adjustment device. In the case of simplex operation of ST-35 equipment (with the same set operating alternately for transmission and reception), the armature of receiving relay P1 (P3) is connected to contact 4B (5B) of adapter K1 (transmission ground wire) through noise-suppression filter L16-C22 (L32-C46), contacts 7-12 of switch B2 (B4) and duct capacitor C59 (C60).

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When making an "against itself" check of the operation of the telegraph channel, switch B1 (B3) is placed in position ПОБ ("CHECK") (position 2 in Figs. 74 and 75). In this case, the receiving branch of the channel is connected to the transmitting branch of the same channel.

When telegraph channel signals are relayed at an intermediate station, switch B1 (B3) is set in position PETP ("RELAY") (position 3 in Figs. 74 and 75). In this case, the frequency-modulated telegraph signals travel from the output of the radio receiver of the particular half-set through contacts 9B-0B of adapter ПK1, contacts of switch B1 (B3), band filter ФТГ-1 (ФТГ-3) and the contacts of switch B1 (B3) to contacts 1B-0B (9c-0B) of adapter ПK1. From these contacts the signals to be relayed reach the transmitting branch of the telegraph channel of the other half-set over contacts 2B-4c of adapter ПK1 (Fig. 74), from where, as explained above, they are fed to the input of the modulation amplifier of the radio transmitter.

The individual elements of the telegraph channels are described below.

Supersonic Frequency Oscillator

The supersonic frequency oscillator is located in the Teleg-1 (Teleg-2) element and uses tube 2 (4) type 12Zh1L (Fig. 76) which functions as a triode (screen and suppressor grids connected to the plate). The oscillator has an oscillatory circuit in the control grid circuit with inductive feedback. The frequency generated (Fig. 76) is determined by grid circuit L12-L13-C20 (L28-L29-C44) and depends on the position of armature Я of transmitting relay P2 (P4). When armature Я is located at right-hand contact П, the oscillatory circuit is formed by the inductance connected between points 14-15 and capacitor C19 (C43). In this case, the lower part of the inductance (between points 13-15) is shorted, while capacitor C20 (C44) is connected to the circuit through large resistance R17 (R50); that is, it is in fact disconnected from the circuit. Meanwhile, the oscillator provides a frequency of 9.1 (12.8) kc. If armature Я of transmitting relay P2 (P4) is located at the left-hand contact Л, the oscillatory circuit is formed by the inductance between points 13-14 and capacitors C19 (C43) and C20 (C44) which are connected in parallel, so that resistance R17 (R50) is shorted, in which case the oscillator produces a frequency of 8.5 (12.2) kc. During the movement of armature Я from one extreme position to the other, the oscillatory circuit is formed by the inductance connected between points 13 and 14 and capacitor C19 (C43). Capacitor C20 (C44) is, in this case, connected to the circuit through high resistance R17 (R50); that is, it is in fact disconnected from the circuit. In this event, the first circuit is full-wave rectifier Л1-Л2 (Л5-Л6), and to the second - rectifier Л3-Л4 (Л7-Л8). If at a given moment of time the frequency of the received signal equals 8.5 (12.2) kc, the current flowing in winding 5-7 (6-8) of receiving relay P1 (P3) will be greater than that flowing in winding 1-3 (2-4) and armature Я of the relay will be located at the left-hand contact. Fig. 78 shows the frequency response characteristic of the telegraph channel, indicating the dependence of the difference of currents L1-L2 in the windings of the receiver relay P1 (P3) on detuning f with respect to the mean frequency of the channel; that is, 8.8 (12.5) kc. In this way, depending on the frequency of the signal received, armature Я of receiving relay P1 (P3) will be located either at the right (П) or at the left (Л) contact, and through

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Техническое описание

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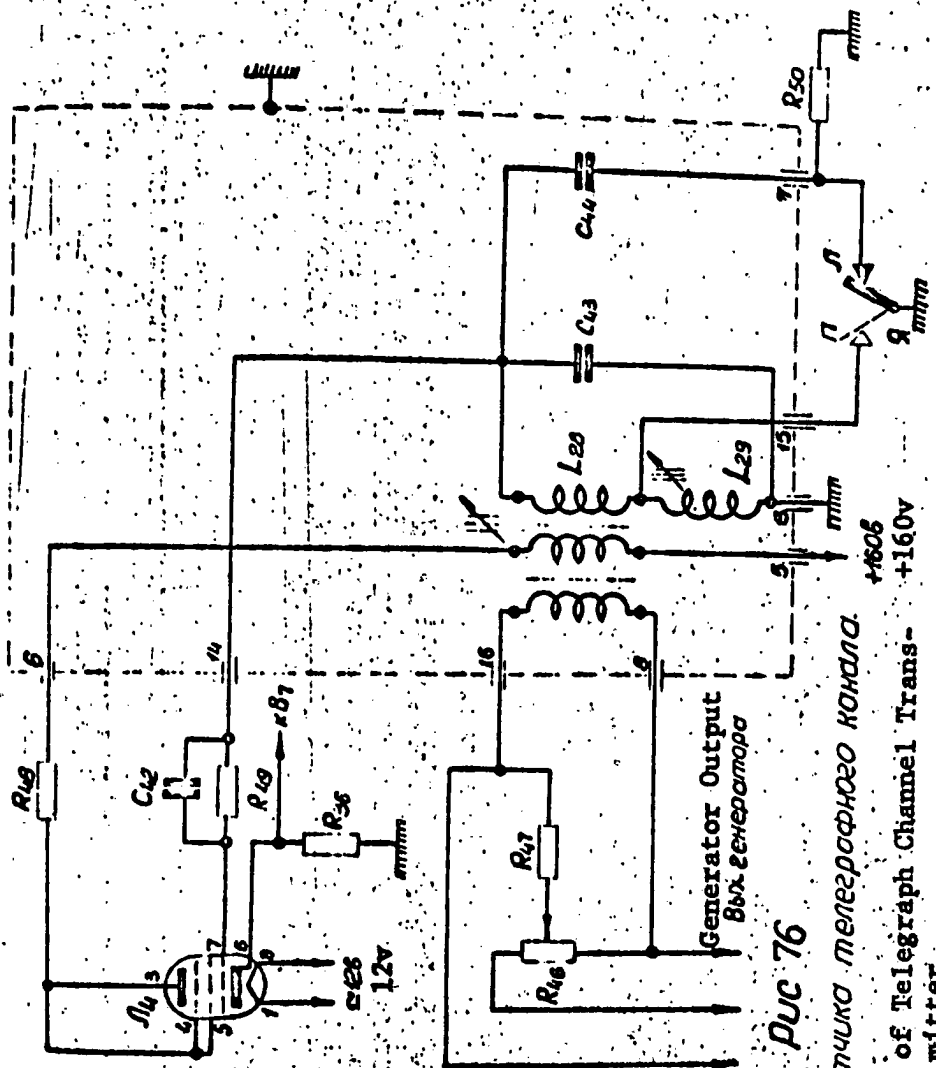


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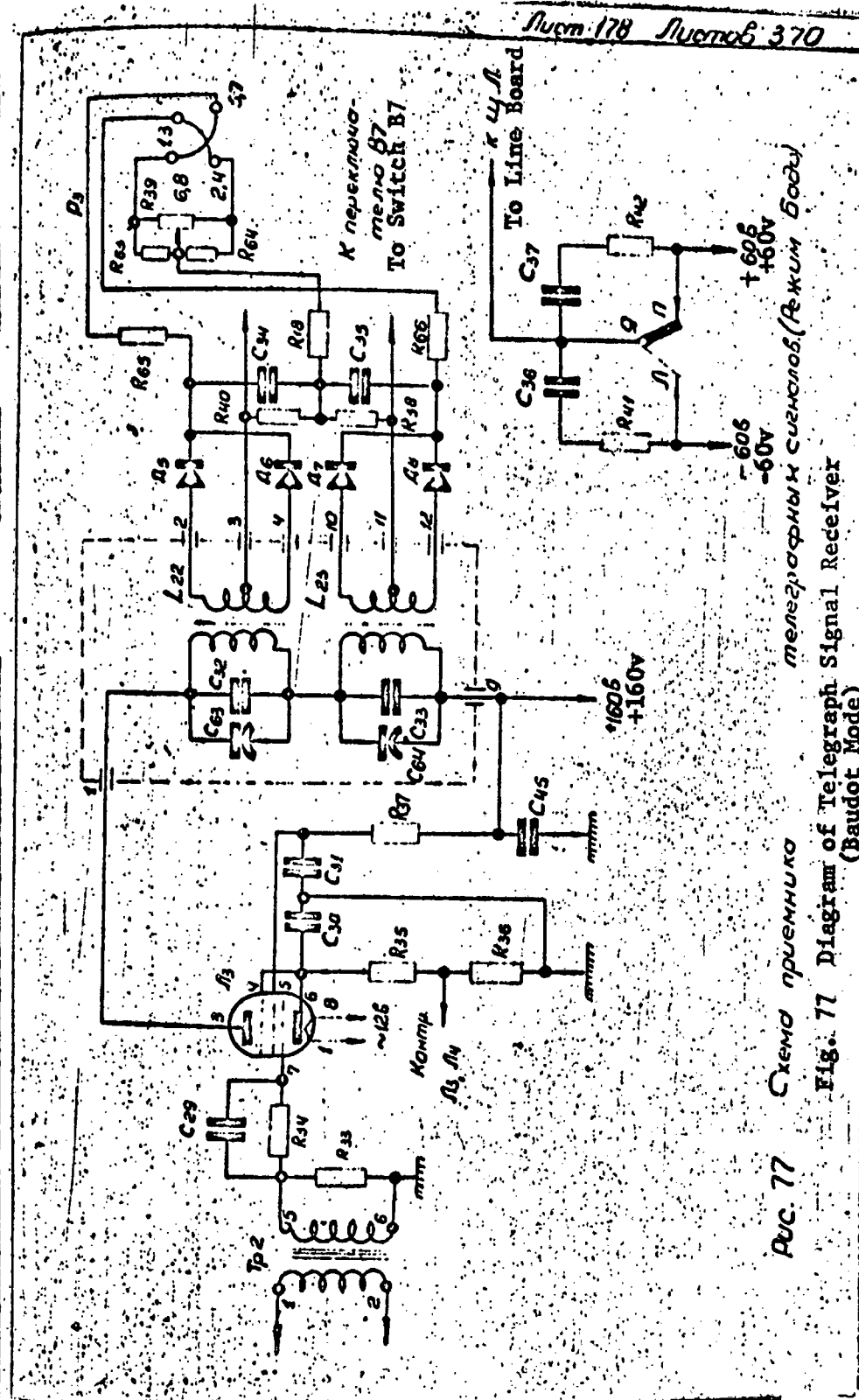
Схема передатчика телеграфного канала

Fig. 76 Diagram of Telegraph Channel Transmitter

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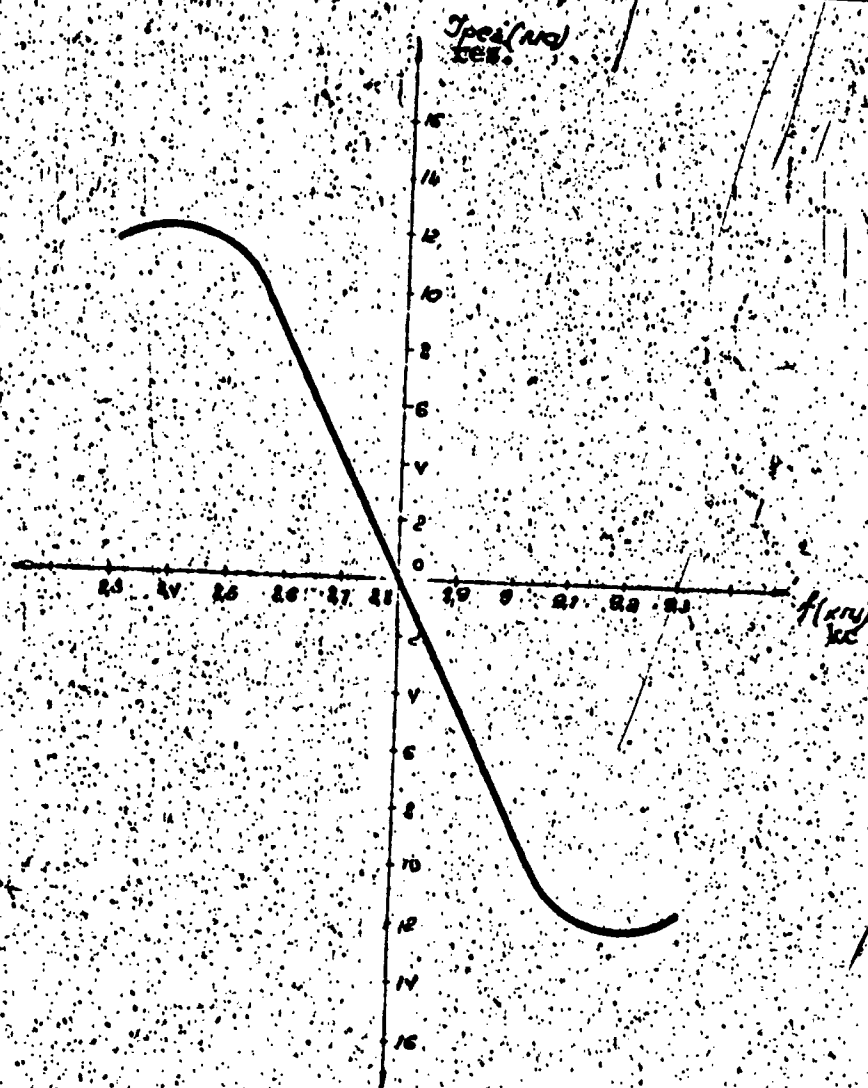


Рис. 78 Характеристика дискриминатора

Fig. 78 Discriminator Characteristic

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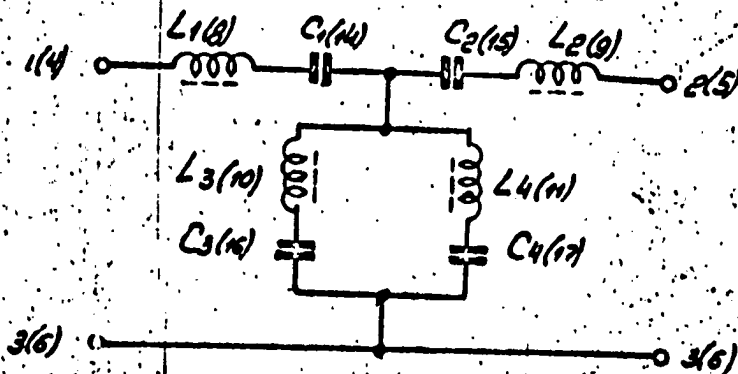
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Лист 181

Лист 182

а) Фильтры 1-го канала

a) Filters of the first telegraph channel



б) Фильтры 2-го канала

b) Filters of the second telegraph channel

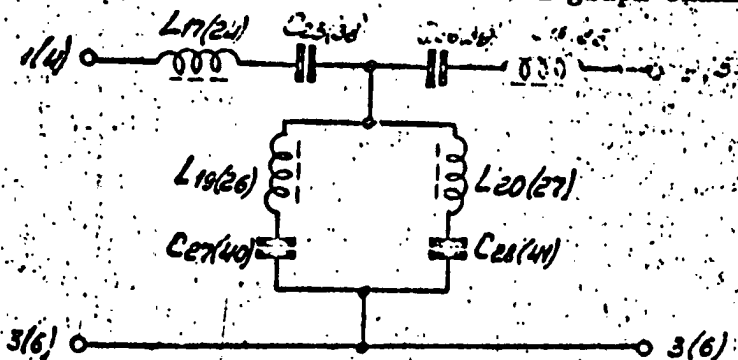


Рис. 79. Схемы фильтров телеграфного блока.

Fig. 79. Diagrams of Filters of the Telegraph Section

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the armature of the receiving relay there is sent to the line circuit of the telegraph set a d-c signal of negative or positive polarity (when working with P-100 equipment) or the making and breaking of the line circuit (of the ST-35 set) (Fig. 78).

Potentiometer R6 (R39) is used to adjust the bias in one of the windings of receiving relay P1 (P3) when adjusting the telegraph channels. The currents in the receiving relay windings are checked by means of indicator Π which is connected through contacts 1-6 (1-8) of switch B7 to resistors R7 and R74 (R40 and R38).

C6, C7, C10, C11, C21 (C30, C31, C34, C35, C45) are blocking capacitors.

Connected between armature $\mathcal{A}$ and contacts $\mathcal{L}$ (left) and $\mathcal{P}$ (right) of receiving relay P1 (P3) are spark-quenching networks R8-C12 and R9-C13 (R41-C36 and R42-C37). Located in the circuits of the armature and contacts are noise-suppression filters L16-C22 and L14-C23 (L32-C46, L31-C48 and L30-C47).

Proper operating condition of amplifier tube $\mathcal{A}1$ ($\mathcal{A}3$) is checked simultaneously with that of tube $\mathcal{A}2$ ($\mathcal{A}4$) of the oscillator, as described above.

Band Filters

The receiving and transmitting band filters of the first telegraph channel $\phi\mathcal{T}\mathcal{C}$ -1 and $\phi\mathcal{T}\mathcal{C}$ -2 and of the second telegraph channel $\phi\mathcal{T}\mathcal{C}$ -3 and $\phi\mathcal{T}\mathcal{C}$ -4 are identical in their electrical circuitry (Fig. 79) and differ only in the rated values of their inductances and capacitances. The inductance coils of the filters are manufactured on Alsifer rings type TChK-55. The filter capacitors are mica, type KS0. The filters are hermetically sealed (Fig. 79).

The passband of the receiving and transmitting filters of the first telegraph channel is 8.4-9.2 kc, and of the second telegraph channel - 12.1-12.9 kc.

The attenuation introduced by the filters over the greater part of the passband is approximately 0.25 nepers. On the frequencies of the other channels of the station the band filters provide an attenuation of not less than 2.45 nepers. The attenuation characteristics of the band filters of the first and second telegraph channels are given in Fig. 62.

Line Circuits

The line circuits of the telegraph channels provide the following types of operation:

- operation by currents of two directions with separate transmission and reception circuits (bipolar operation);
- operation by the current of one direction with separate transmission and reception circuits (two-wire simplex);
- operation by the current of one direction with transmission and reception circuits not separated (single-wire simplex).

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The transition from one form of operation to another is accomplished by means of switch B2 (B4), the control for which is remoted to the front panel of the section (Fig. 72, No. 6). It is also possible by means of the same switch to send to the radio link frequencies corresponding to the current (marking) and no-current (spacing) pulses from a telegraph set.

A detailed description of each form of operation is given below.

In order to illustrate the armature position of type RP-4 telegraph relay in its basing (Fig. 80), arrows have been used to indicate that direction of the current in its windings which causes armature $\mathcal{A}$ to be located at right-hand contact $\mathcal{B}$. If the current flows through the relay windings in the opposite direction, the armature will be located at left-hand contact $\mathcal{A}$ (Fig. 80).

Bipolar Operation

This mode of operation is employed when working with P-100 telegraph sets and also for effecting through telegraph connections (rehandling). In this case, the telegraph channel operating mode switch B2 (B4) is set at position $\mathcal{B}\mathcal{O}\mathcal{A}\mathcal{O}$ ("BAUDOT").

In bipolar operation the transmission and reception circuits are distinct (Fig. 81). The telegraph line circuits for transmission are fed, in this case, from the P-100 end, and the reception line circuits - from the R-401M end.

Let us consider the transmission circuit (see basic diagram and Fig. 81). The transmission line current circuit is made in the following fashion: contact 3a (7a) of adapter K1, duct capacitor C51 (C58), contacts 3-2 of jack $\mathcal{F}1$ ($\mathcal{F}2$), potentiometer R22 (R54), test resistor R21 (R53), resistor R19 (R51), winding 1-2 of transmitting relay P2 (P4), contacts 1-4 of switch B2 (B4), duct capacitor C50 (C60), contact 4B (5B) of adapter $\mathcal{N}K1$. Potentiometer R22 (R54) is used to set the input current of 25 ma. The value of this current is checked by means of indicator device $\mathcal{M}\mathcal{N}$ which is connected to test resistor R21 (R53) through contacts 1-4 (1-10) of switch B7. When a plus pulse is sent from the telegraph set, the current in winding 1-2 of transmitting relay P2 (P4) flows in a direction from the first contact to the second contact of this winding, with armature $\mathcal{A}$ of the relay located at right-hand contact ($\mathcal{B}$), and a 9.1 (12.8) kc signal will be sent into the radio line. With a minus pulse sent from the telegraph set, current in winding 1-2 of the transmitting relay will flow from the second contact to the first, armature $\mathcal{A}$ of the transmitting relay will be located at the left-hand contact ($\mathcal{A}$) and a signal with a frequency of 8.5 (12.2) kc will be sent out over the radio link. The remaining windings of transmitting relay P2 (P4) are disconnected during bipolar operation by means of switch B2 (B4) and play no part in the operation.

Let us now consider the reception circuit. When a signal of a frequency of 9.1 (12.8) kc is received from the radio line, the current in windings 1,3 - 2,4 of receiving relay P1 (P3) will be larger than the current in windings 5,7 - 6,8, as noted above. Meanwhile, the current in parallel-connected windings 1-2 and 3-4 will flow in direction 1-3 and 2-4 and armature $\mathcal{A}$ of the receiver relay will be located at right-hand contact. When an 8.5 (12.2) kc signal is received, the greater current will flow through parallel-connected windings 5-6 and 7-8 in direction 5-7 and 6-8 and the armature of the relay will be located at left-hand

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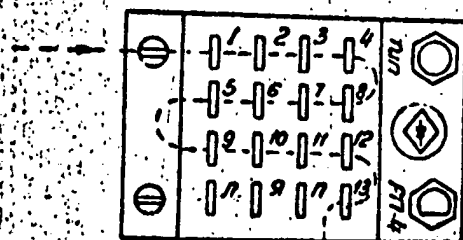
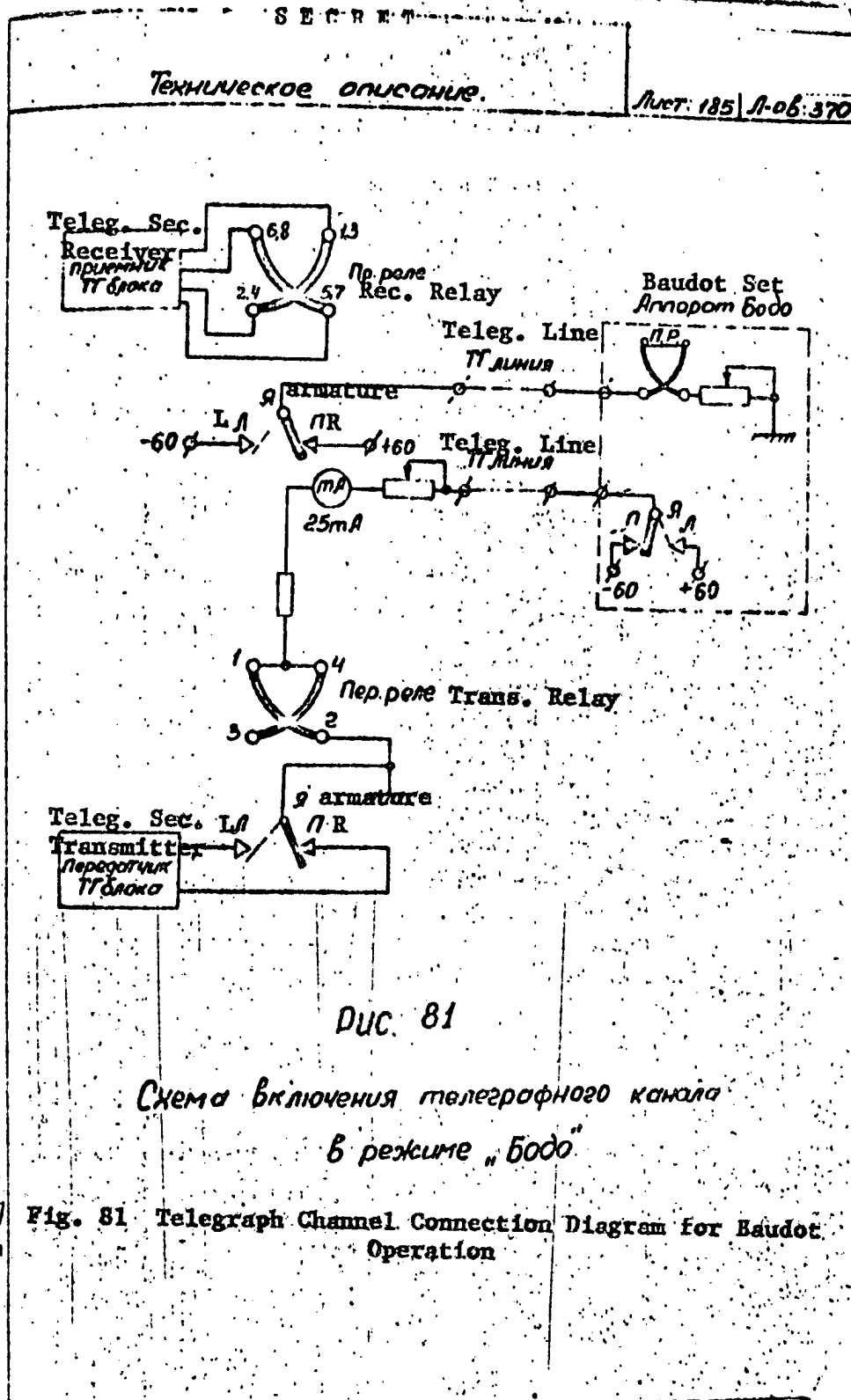


Рис. 80. Направление тока в обмотках поляризованного реле типа РП-4, при котором якорь перебрасывается к правому контакту.

Fig. 80 That Direction of the Current in the Windings of Type RP-4 Polarized Relay which Causes the Armature to Move to the Right-Hand Contact

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contact Π). To the contacts of relay P1 (P3) a voltage is fed from the line circuit feed unit: +60 volts through contact 2-1 or 4-1 of power-mode switch B5 (B6), resistor P32 (P61), contacts 10-7 of switch B2 (B4) and noise-suppression filter C24-L15 (C48-L31) - to right-hand contact Π ; -60 volts through contacts 10-9 or 12-9 of power mode switch B5 (B6), resistor R31 (R60), contacts 4-1 of switch B2 (B4) and noise-suppression filter C23-L14 (C47-L30) - to the left-hand contact Π . The reception line current circuit is made as follows: from +60v or from -60v of the line circuit feed element to the right or left contact of receiving relay P1 (P3) - as outlined above; further, from the armature of the receiving relay through noise-suppression filter L16-C22 (L32-C46), contacts 7-10 of switch B2 (B4), test resistor R27 (R59), contacts 4-5 of jack Γ 1 (Γ 2), resistor R28 (R62), duct capacitor C49 (C56), contact 1a (5a) of adapter K1, through the line board, connecting line, telephone set, through contact 2B (6a) of adapter Π K1, duct capacitor C50 (C57) made at midpoint Cp.T of the line circuit feed element.

The current in the receiving circuit is adjusted only at the telegraph set. The outgoing current in the receiving circuit is adjusted by means of indicator device Δ 11 which is connected to test resistor R27 (R59) through contacts 1-3 (1-11) of switch B7.

Resistors R31 and R32 (R60 and R61) serve to protect the feed circuits against heavy currents when the circuits are made in the contact system of the receiving relay (left contact-armature-right contact).

Two-Wire Simplex

This mode of operation is employed when it is necessary to provide simultaneous transmission and reception over a telegraph channel through the use of ST-35 start-stop telegraph equipment. There are connected to the channel (through the line board) two ST-35 sets: the transmitting set to contacts 3a-4B (7a-5B), and the receiving set to contacts 1a-2a (5a-6a) of adapter Π K1. The telegraph channel operation selecting switch B2 (B4) is set in position 2 Δ P ("TWO-WIRE"). The telegraph line circuits for transmission and reception are powered in this case only from the ST-35 end from batteries of any polarity. In two-wire simplex the transmission and reception circuits, just as in bipolar operation also, remain separate (see basic diagram and Fig. 82).

The telegraph circuits in two-wire simplex have the following special features:

Two line coils 1-2 and 3-4 are connected in transmitting relay P2 (P4). Connected in series with these coils are germanium diodes Δ 9 and Δ 10 (Δ 11 and Δ 12).

When working from batteries of positive polarity, line coil 1-2 is operative, while when working with batteries of negative polarity, coil 3-4 is operative. The ampere-turns of the line coils always operate on the relay armature in one direction. In this way, unipolar operation is assured from batteries of either polarity without additional switching.

For operation of the polarized neutrally-adjusted cross-over relay, for the control of unipolar current pulses, in addition to the line windings, field windings 5-6 and 7-8, connected in series (and shown in the diagram in the form of

the one winding 5-8) are also connected. The effect of the line windings and field windings (magnetization windings) on the armature of transmission relay P2 (P4) is opposite. The field windings are constantly under current, the value of which is 2-3 times less than the current in the line windings. For this reason, in the case of a no-current pulse, only the ampere-turns of the field windings will effect the armature of the relay, which will be located at the left-hand contact Л. A signal with a frequency of 8.5 (12.2) kc is sent over the radio line. If current flows over the line windings, the ampere-turns of these windings will exert a predominant effect on the relay armature and this armature Я will be located at right-hand contact П, with a 9.1 (12.8) kc signal sent to the radio line.

The transmission line current circuit, when operating from a battery of positive polarity, is made in the following fashion: contact 3a (7a) of adapter ПК1, duct capacitor C51 (C58), contacts 3-2 of jack f1 (r2), potentiometer R22 (R54), test resistor R21 (R53), resistor R19 (R51), winding 1-2 of transmitting relay P2 (P4), contacts 1-5 of switch B2 (B4), germanium diode Д10 (Д12), contacts 5-1 of switch B2 (B4), duct capacitor C59 (C60), contact 4B (5B) of adapter ПК1.

The transmission line current circuit, when operating from a battery of negative polarity, is made in the following fashion (from plus to minus): contact 4B (5B) of adapter ПК1, duct capacitor C59 (C60), contacts 1-5, switch B2 (B4), germanium diode Д9 (Д11), winding 3-4 of transmitting relay P2 (P4), resistor R19 (R51), test resistor R21 (R53), potentiometer R22 (R54), contacts 2-3 of jack f1 (r2), duct capacitor C51 (C58), contact 3a (7a) of adapter ПК1.

The input current in the order of 50 ma is adjusted in both cases by means of potentiometer R22 (R54). This current is checked by means of indicator device ИИ, just as in the case of bipolar operation.

The magnetizing circuit current is made as follows: +60v of the line circuit feed element, contacts 2-1 or 4-1 of switch B5 (B6), potentiometer R26 (R58), contacts 11-7 of switch B2 (B4), field windings 5-6 (7-8), resistor R24 (R56), test resistor R25 (R57), midpoint Cp.T of the line circuit feed element. With the magnetizing current constant, the distortions introduced by the transmitting relay (depending on the type, length and condition of the wire line) may be as high as 20%. For this reason, provision has been made in the circuit for the possibility of changing the magnetizing current by means of potentiometer R26 (R58), the control for which has been remoted to the front panel of the section under the slot (Fig. 72, No. 9). The magnetizing current is checked by means of indicator device ИИ which is connected to test resistor R25 (R57) through contacts 1-5 (1-9) of switch B7.

When receiver relay P1 (P3) operates, its contacts make and break the line circuit of the telegraph set. When an 8.5 (12.2) kc signal is received, corresponding to a spacing (no-current) pulse, the greater current will flow through windings 5-6 and 7-8 in direction 5-6 and 7-8 and armature Я of receiving relay P1 (P3) will be located at the left-hand contact (Л). Meanwhile, the receiving line current circuit will be open, corresponding to the reception of a spacing (no-current) pulse. When a 9.1 (12.8) kc signal is received, corresponding to a marking (current) pulse, the greater current will flow through windings 1-2 and 3-4 in direction 1-2 and 3-4 and armature Я of receiving relay P1 (P3) will be

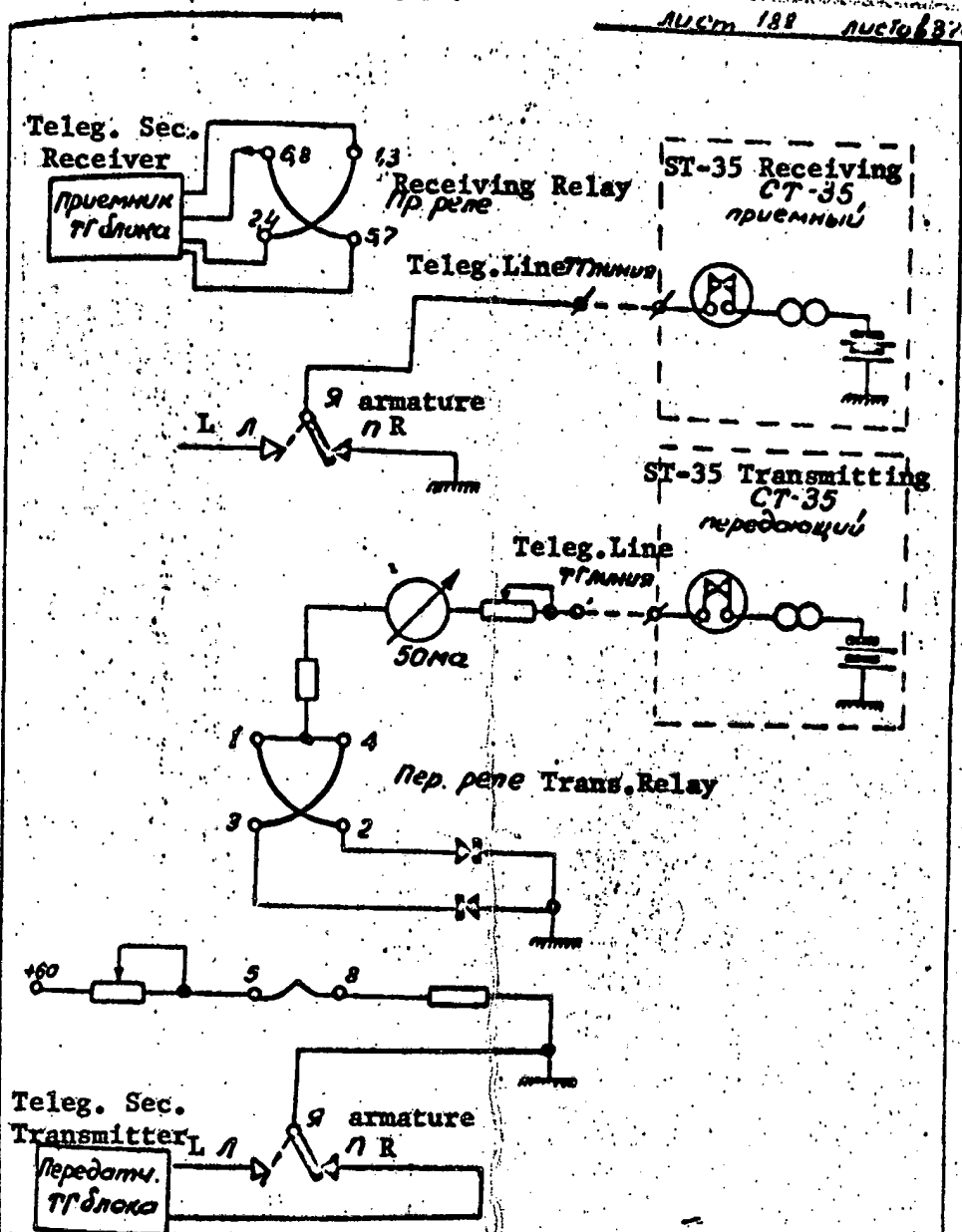


Рис. 82 Схема включения телеграфного канала в режиме "симплекс двухпроводный"

Fig. 82 Telegraph Channel Connection Diagram for Two-Wire Simplex Operation

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located at the right-hand contact (П). Meanwhile, the receiving line current circuit will be closed, corresponding to the reception of a marking (current) pulse.

The reception line current circuit is made as follows: contact 1a (5a), duct capacitor C49 (C56), resistors R28, R61 (R62, R68), contacts 5-4 of jack П1 (П2), resistor R27 (R59), contacts 11-7 of switch B2 (B4), noise-suppression filter C22-L16 (C46-L32), armature Я, right-hand contact П of receiving relay П1 (P3), noise-suppression filter L15-C24 (L31-C46), contacts 7-11 of switch B2 (B4), duct capacitor C50 (C57), contact 2a (6a) of adapter ПК1.

The outgoing current in the receiving circuit is adjusted only at the receiving telegraph set and checked by means of indicator device ИП, just as in bipolar operation.

Single-Wire Simplex

This mode of operation is designed for simplex (alternating) operation of ST-35 start-stop telegraph equipment (see basic diagram and Fig. 82). In this case, one telegraph set is connected to the channel. Telegraph channel operation selecting switch B2 (B4) is set in position 1П ("SINGLE-WIRE"). The line circuit, in this mode, is fed only on the ST-35 end from a battery of either polarity (Fig. 83).

Single-set operation for reception and transmission is provided by the fact that the line circuit is made through the line coils of the transmitting relay and the right-hand contact of the receiving relay, while the circuit of the transmitting relay holding winding is made through the right-hand contact of the receiving relay. In transmitting relay П2 (P4), field windings 5-6 - 7-8 are constantly under current. The magnetizing current circuit is made in the same manner as in the two-wire simplex mode. When working from a battery of positive polarity, the line circuit from contact 3a (7a) of adapter К1 to germanium diode Д10 (Д12), inclusive, is the same as in the two-wire simplex mode. Further, the line current circuit is made as follows: contacts 12-7 of switch B2 (B4), noise-suppression filter C24-L15 (C48-L31), right-hand contact П, armature Я, receiving relay П1 (P3), noise-suppression filter L16-C22 (L32-C46), contact 7-12 of switch B2 (B4), duct capacitor C59 (C60) and contact 4B (5a) of adapter ПК1.

When operating from a battery of negative polarity, the line circuit (from plus to minus) from contact 4B (5B) of adapter ПК1 to germanium diode Д10 (Д12) runs in reverse order to the preceding case. Further, through germanium diode Д9 (Д11) to contact 3a (7a) of adapter ПК1, the line circuit is made in the same fashion as in the two-wire simplex mode.

When a signal, corresponding to a marking (current) pulse is received, armature Я of receiving relay П1 (P3) will be located at the right-hand contact (П). In this case, the line circuit will be closed, as explained above, and armature Я of the transmitting relay will be located at the right-hand contact (П).

When a signal, corresponding to a spacing (no-current) pulse, is received, armature Я of receiving relay П1 (P3) will be located at the left-hand contact (Л). In this case, the line circuit will be open. However, armature Я of transmitting relay П2 (P4) will remain at the right-hand contact (П) under the influence of the ampere-turns of its holding winding 12-13, thus providing for the

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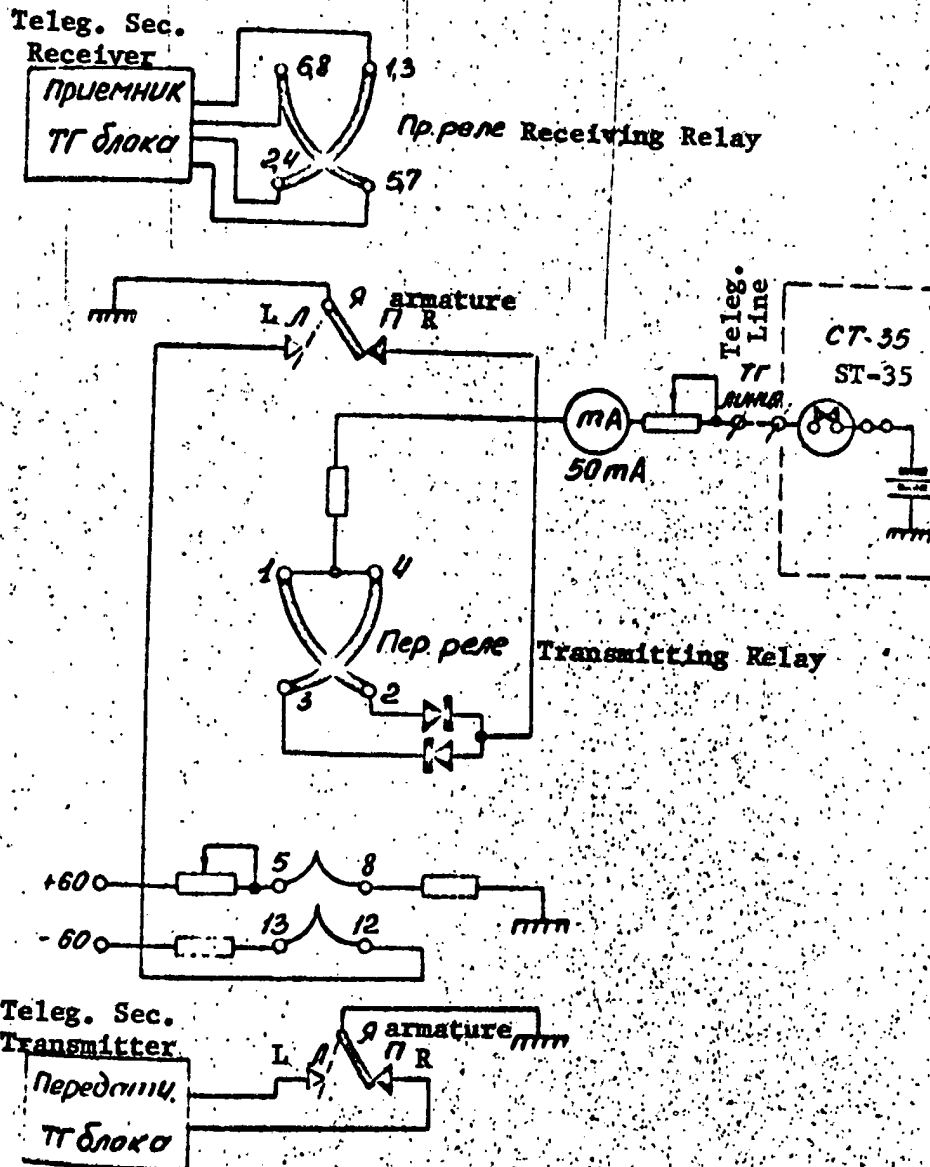


Fig. 83

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transmission into the radio line of a 9.1 (12.8) kc frequency, corresponding to a marking (current) pulse. This in turn makes the line circuit of the correspondent's telegraph set.

Spark-quenching networks R8-C12-C13-R9 (R41-C36-C37-R42) prevent the operation of the transmitting relay armature during the time the receiving relay armature is traveling from one contact to another.

In order to make the current circuit of holding winding 12-13 of the transmitting relay, when operating a telegraph channel in single-wire simplex, switch B1 (B2) of the line board must be set in position ~~BACK~~ ("OFF") or ITT (ITT) when working over a midpoint; then, contacts 2a-4B (6a-5B) of adapter NK1 will be interconnected by means of switch B1 (B2) of the line board (see Section 8 of this Chapter). Meanwhile, the current circuit of the transmitting relay holding coil P2 (P4) will be made as follows: midpoint Cp.T of the line circuit feed element, duct capacitor C60 (C57), contacts 2B-4B (6a-5B) of adapter NK1, duct capacitor C59 (C60), contacts 12-7 of switch B2 (B4), noise-suppression filter C22-L16 (C46-L32), armature A, left-hand contact N of receiving relay P1 (P3), noise-suppression filter L14-C23 (L30-C47), contacts 1-6 of switch B2 (B4), holding winding 12-13 of transmitting relay P2 (P4), resistor R23 (R55), contacts 9-12 or 9-10 of switch B5 (B6), minus 60v of the line circuit feed element.

Transmission of Frequencies Corresponding to Marking and Spacing Pulses

When checking the operability of a telegraph channel over the radio link or when making a back-to-back check by means of switch B2 (B4) and transmitting relay P2 (P4), it is possible to transmit in the direction of the radio link, or to one's own receiving branch, frequencies which correspond to a negative or positive pulse. Switch B2 (B4) is set at the "plus" or "minus" position, respectively. In this case, the receiving branch of the channel operates as in bipolar operation. At transmitting relay B2 (B4), the circuits of line windings 1-2 and 3-4 and holding winding 12-13 are opened by means of switch B2 (B4).

The current flows in field winding 5,6 - 7,8 in a direction such that when a positive pulse is transmitted, the transmitting relay armature is located at the right-hand contact, with a 9.1 (12.8) kc signal sent to the radio line; when a negative pulse is transmitted, the transmitting relay armature is located at the left-hand contact, with a 9.5 (12.2) kc signal sent to the radio line.

When a positive pulse is sent, the field winding current circuit is made as follows: midpoint Cp.T of the line circuit feed element, test resistor R25 (R57), resistor R24 (R56), field winding 8,7 - 6,5, contact 7-9 of switch B2 (B4), contacts 9-10 or 9-12 of switch B5 (B6), minus 60v of the line circuit feed element.

When a negative pulse is sent, the field winding current circuit is made as follows: plus 60v of the line circuit feed element, contacts 2-1 or 4-1 of switch B5 (B6), contacts 8-7 of switch B2 (B4), field winding 5,6 - 7,8, resistor R24 (R25), test resistor R25 (R57), midpoint Cp.T of the line circuit feed element.

The current is checked in the field winding by means of indicator device NN as discussed in the Section dealing with "Two-Wire Simplex".

8.

Line Board

The line board is an integral part of every half-set. It is used for the connection of telephone and telegraph lines when operating from a half-set removed from the station van. When the equipment is located within the van, each line board is connected with the proper rack by means of cable $\mathcal{W}$ -5 and with the proper van recess (port) by means of cable $\mathcal{W}$ -6.

Design of the Board

The line board is designed as an independent portable unit. An external view of the board is given in Fig. 84.

The principle design feature of the line board is the front panel to which a casing is attached by means of screws. The rear wall of the casing is removable. It is fastened to the side walls of the casing and is equipped with corner brackets by means of which the line board is attached to the forward wall of the van. Above the casing there is a shielded bell. On the lower wall of the casing are plugs for cables $\mathcal{W}$ 5 and $\mathcal{W}$ 6 and a grounding terminal. On the side walls of the casing are catches for fastening the top of the front panel of the board. The dimensions of the line board (with the top closed) are 320 X 330 X 140 mm. The board weighs 7.5 kg.

Circuitry of the Board

A basic diagram of the line board is given in Vol. 2. By means of cable $\mathcal{W}$ 5 the circuitry of the line board is connected with the circuitry of the corresponding half-set of the station. All the telephone and telegraph channel input and output lines, with the exception of the telegraph channel ground conductors, run from plug $\mathcal{W}$ 5 to connecting terminals 1-18 of the line board through safety fuses type PK-45-0.25 Пп1, Пп18 and excess voltage suppressors ПНН -ПН8. In this way, lightning protection for each communication line is provided.

All terminals 1-21 of the line board are connected with the identically numbered terminals of the corresponding input recess (port) in the van by means of cable $\mathcal{W}$ 6.

The transmission conductors of both telegraph channels have noise-suppression filters C1-P1 and C3-P2. The receiving lines of these channels are blocked to ground over capacitors C2 and C4.

The line board has two line transformers. By means of line transformer Tп1 and switch B1, the operation of an ST-35 telegraph set in simplex or the operation of P-100 or ST-35 telegraph sets transmitting in duplex can be sent from a communication center to the first telegraph channel of the station over the midpoint of the first telephone channel connecting line*. By means of line transformer Tп2

* When working the telegraph channel in a four-wire system, the telegraph operation is fed over the midpoint of the receiving wire - terminals 1-2 (5-6) of the line board.

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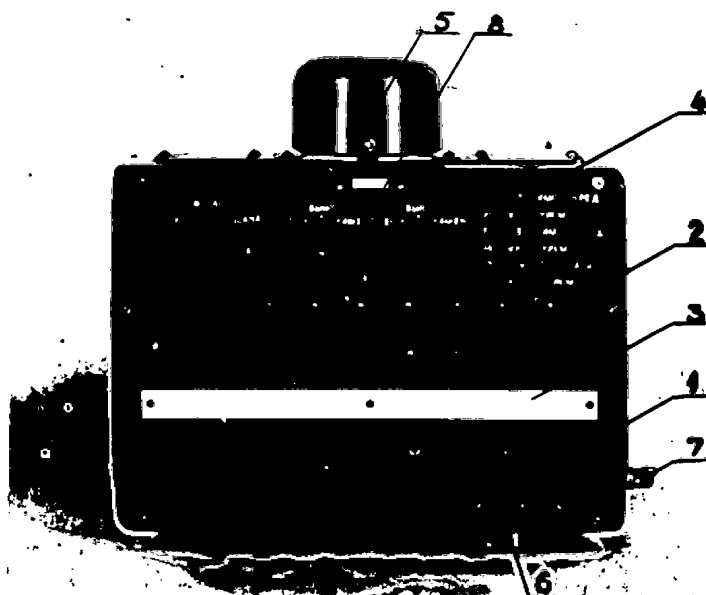
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FIG. 84 - Line Board

1. Wire Line Connecting Terminals
2. Fuses
3. Call Letter Plaque
4. Line Circuit Switches (B_1 , B_2)
5. Bell
6. Connecting Plugs for Cables W_5 and W_6
7. Grounding Terminal
8. Identification Shield

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and switch B2 the operation of an ST-35 in simplex or that of P-100 and ST-35 telegraph sets transmitting in duplex can be carried from a communications center to the second telegraph channel of the station over the midpoint of the second telephone channel connecting line (see footnote on page 147).

With switch B1 (B2) set in position *ВЫКЛ* ("OFF"), line transformer Tpl (Tp2) has no part in the operation. In this case, the two-wire input of the telegraph channel (the receiving branch of the channel in the case of four-wire operation), contacts 1-2 (5-6) of the *Ш* 5 plug, are connected with terminals 1-2 (5-6) of the line board through contacts 5-7-8-12-11-9 and contacts 1-3-4-4-3-1 of switch B1 (B2). The reception ground wires (terminal 19) and the transmission ground wires (terminals 21 and 20) of both telegraph channels are connected with ground through contacts 3-1 or 7-5 of switch B1 (B2).

With switches B1 (B2) set in position *4ПР ИТГ* (*4ПР ИТГ*) (i.e., "FOUR-WIRE 1ST OR 2ND TG CHANNEL") line transformer Tpl (Tp2) also has no part in the operation. The two-wire input of the telephone channel is connected with terminals 1-2 (5-6) of the line board as in the preceding case. The reception and transmission ground wires of the telegraph channels are disconnected from the ground. In this case, the ST-35 or P-100 telegraph sets, operating in duplex, are connected to the station by means of four-wire connecting lines to the terminals of the input recess (van ports) or of the line board in accordance with the markings on the latter's front panel.

With switch B1 (B2) set in position *ИТГ* (*ИТГ*) ("1ST OR 2ND TG CHANNEL") line transformer Tpl (Tp2) is connected.

Winding 1-4 of the transformer is connected to contacts 1-2 (5-6) of plug *Ш* 5 through contacts 6-5 and 2-1 of switch B1 (B2). Winding 5-8 is connected to terminals 1-2 (5-6) of the line board through contacts 9-10 and 2-1 of switch B1 (B2). The midpoint of the winding is connected to contact 11 (13) of the plug *Ш* 5 through contacts 9-10 of switch B1 (B2) and noise-suppression filter PO-C1 (P2-C3). The reception and transmission ground wires, meanwhile, are connected with ground through contacts 2-1 or 6-5 of switch B1 (B2). In this way, with duplex operation of ST-35 or P-100 telegraph equipment, the telegraphy operation may be transmitted from the communication center to the station over the midpoint of the corresponding telephone line.

In this case, the receiving branch of the telegraph channels of the station (terminals 12 and 14) must be connected with the receiving telegraph sets by additionally installed connecting lines.

In the case of ST-35 simplex operation, transmission and reception may also be effected over the midpoint of the telephone line connecting the communication center to the station.

Terminals 9-10 of the input recess and line board are used to connect the junction line of the service communication telephone set.

From contacts 24-18 of plug *Ш* 5 a ± 60 v voltage is fed to block *А* 1, located on the left of the front panel of the line board and used to connect the feed wire for the device employed in adjusting the telegraph channels.

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From contact 21 of plug $\mathbb{W}$ 5 the voltage from the storage battery (12v) is fed to block $\mathbb{F}$ 2, located on the right of the front panel of the line board and used to connect a portable light or soldering iron.

The 12v voltage is fed to bell 3B from contact 26 of plug $\mathbb{W}$ 5. Between contacts 21 and 26 of plug $\mathbb{W}$ 5 diode $\mathbb{A}$ 1 is connected so that in the event of an incorrect connection of the storage batteries (confused polarity) the diode opens and makes the feed circuit of bell 3B. The bell in this case, will ring, indicating that the storage batteries have been improperly connected.

9.

Station Power Supply Unit

Block Diagram of the Station Power Supply

The primary power supply sources for the station, depending upon the specific operational conditions, are the 12-volt storage battery groups or the single-phase 127/220-volt power mains.

Every station half-set has three storage battery groups each consisting of two storage batteries (type 5NKN-45) connected in series. The rated voltage of a group is 12v. The storage batteries are connected with the charging boards of the particular half-set by means of cable $\mathbb{W}$ 8 (Figs. 85 and 86). From the charging board the voltage of the operating group is fed over cable $\mathbb{W}$ 3 to the transmitter, the telephone and telegraph sections and over cable $\mathbb{W}$ 16 to the power amplifier section (6JM).

In the truck version of the station, when power is derived from the storage batteries, the voltage travels from the charging board through cable $\mathbb{W}$ 17 for the illumination of the van, while in the case of mains power supply, the voltage for van illumination is drawn from the mains board through cable $\mathbb{W}$ 13.

The storage batteries in the fixed station and in the truck station (when not in motion) are charged from gasoline-driven battery charger PES-0.75, which consists of a 2SDV motor and a GSK-1500 generator, or from an AB-1-P/30 gasoline-electric battery charger, consisting of a 2SDV motor and a GAB-1-P/30 generator.

In the fixed station, the battery charger is connected with the charging board by cable $\mathbb{W}$ -9-H-3.

In the truck station, when charging the storage batteries, the PES-0.75 or AB-1-P/30 charger is removed from the vehicle and connected with the input recess (plug "12 + 27v") by means of cable H-3. In the van of the truck the plugs "12 + 27v" of the input recesses are connected by cables $\mathbb{W}$ -9 with the charging boards.

When the PES-0.75 battery charger is used, the drive of generator GSK-1500 is regulated over the same cables ($\mathbb{W}$ 9 and H3) by a field rheostat located in the charging board. When the AB-1-P/30 charger is employed, the generator GAB-1-P/30 is controlled by means of a rheostat located in the control section of the charger (the field rheostat in the charging board of the station plays no part in the operation in this last case).

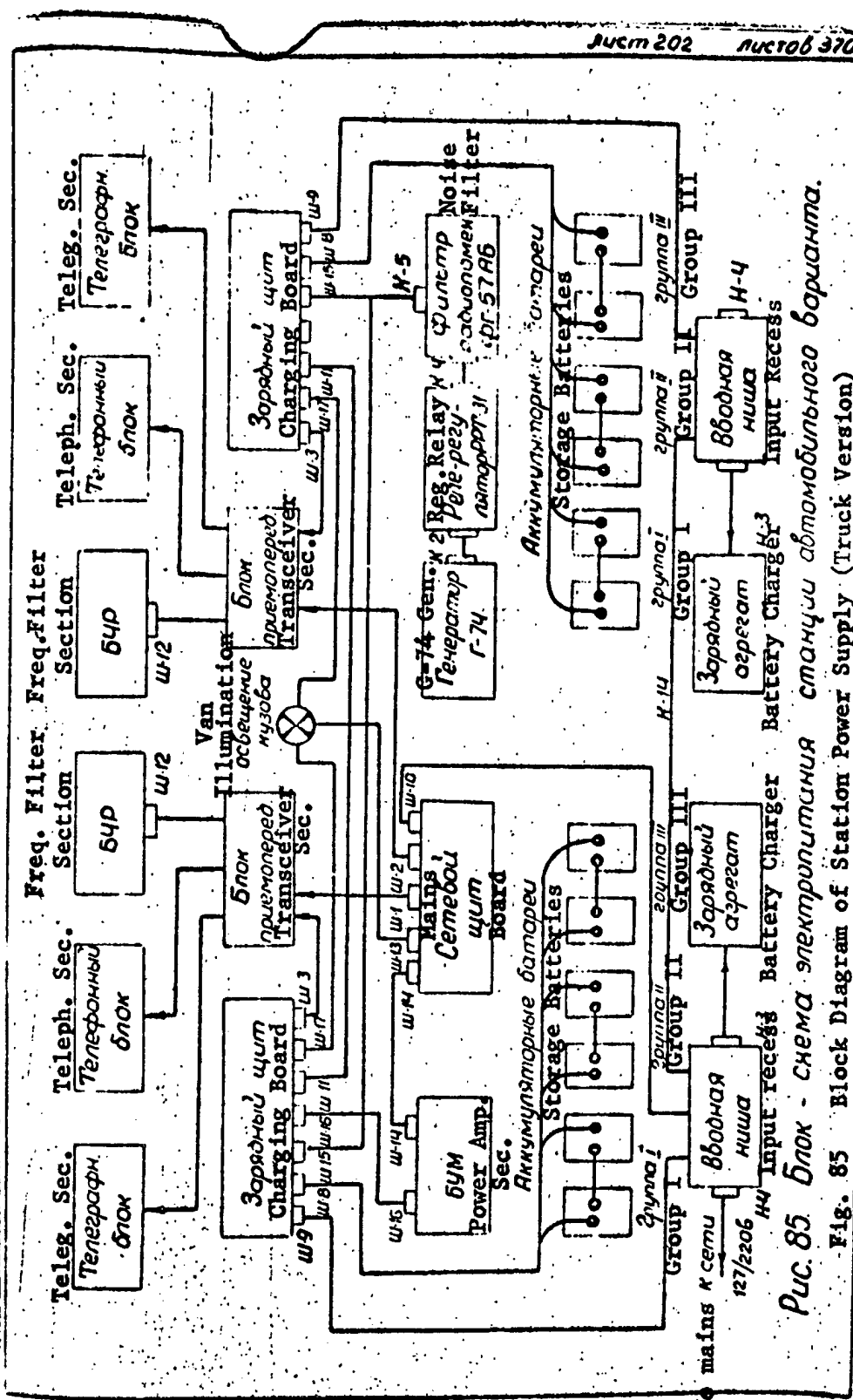


Рис. 85 Блок - схема электропитания станции автомобильного варианта.

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Fig. 86 Block Diagram of Station Power Supply (Fixed Version)

Рис. 85 блок-схема электропитания станции стационарного борисанта

S-E-C-R-E-T

In the truck station, the storage batteries may be charged from a G-71 generator driven from the truck gearbox. The G-71 generator may be used to charge the storage batteries both when the truck is in motion as well as when parked.

The charging boards are interconnected by cable 11, which makes it possible to charge any storage battery group of each half-set from a single battery charger by connecting it to any of the charging boards. For simultaneous charging from a battery charger, the storage battery groups may be taken in any combination of not more than two. Generator G-74 permits a simultaneous "fast" charge of four battery groups (by a 22.5 ampere current) or of all six groups by a normal charging current of 11.25 amperes.

The station may also be powered from the a-c 127/220v mains. The a-c mains are connected by means of cable 10 to the mains board of the fixed station or by means of cable H4 to either of the input recesses of the truck van by means of the plug marked "127/220v".

The "127/220" plugs in both input recesses are interconnected by means of cable K14. From the "127/220" plug of the left recess mains power is fed to the mains board by means of cable 10. The mains board provides for the cut-in, control and monitoring of the mains voltage reaching all the sections of the station over cables 1 (2).

The plate-screen circuits, bias circuits, filament circuits of the tubes and transceiver, telephone and telegraph sections draw their voltage from transistorized converters (feed elements). Each half-set contains three feed elements:

- Transmitter feed element,
- Receiver feed element,
- Line circuit feed element.

In addition, the power amplifier section has its own feed element.

With the station powered from the a-c mains, the voltage (+12v) is fed to the suppressor grid of the tube of the transmitter input stage, the microphone, the amplitude limiters and ringing relays from the rectifiers located in the mains board through cables 1 and 2. When the station is fed from storage batteries, the voltage (+12v) is fed to these circuits directly from the battery group under charge.

Feed Elements

The feed elements of the transmitter, receiver and line circuits are contained in individual standardized mounting frames of cast Silumin (Figs. 24, 25 and 73).

The feed element of the power amplification section is mounted in the Silumin frame of the power amplifier (Fig. 40). To provide for shielding and elimination of radio interference, the mounting frames are divided into separate compartments housing the circuit elements. For ease of assembly and repair, the

frames are provided above and below with removable covers. The feed elements of the transmitter, receiver and line circuits are fastened to the proper sections by means of hinges and a Dzuz-type screw (Figs. 25 and 73).

Basic diagrams of the feed elements are given in Figs. 87 and 88. The operational principle of all the feed elements is the same. When storage batteries are used for power supply, the low-voltage direct current is converted into a high-voltage direct current. This is achieved by converting the d-c voltage of the storage batteries into an a-c voltage by raising it through transformer Tpl to the necessary value and by further rectifying it through germanium diodes (Fig. 77).

The conversion of the d-c voltage of the storage batteries into an a-c voltage in the feed elements of the transmitter, receiver and line circuits is accomplished by means of a converter using crystal diodes type P4V. This converter is a push-pull, self-exciting oscillator, the crystal triodes of which are connected in a circuit with a common emitter (Fig. 87). The converter consists of crystal triodes T1 and T2, operating in a "keying" mode (open-close), and transformer Tpl to provide the feedback for sustained oscillations and also the necessary d-c voltages for further rectification. The converter operates in the following fashion:

When the power supply is switched on from the storage batteries, contacts A and B of adapter block $\Pi-1$ ($\Pi-2$ or $\Pi-3$) are bridged by means of the proper switches and a +12v is fed through noise-suppression filter C9AP2-C10 to resistors R1-R2. Because of the voltage drop in resistor R1, a small negative bias is fed to the base of triodes T1 and T2 through branches 7-6 and 6-5 of winding II of transformer Tpl. An initial current of small amplitude appears in the collector circuit of both triodes.

Due to the asymmetry of the triodes, the currents in branches 2-1 and 3-4 of winding I of transformer Tpl will be unequal, causing the appearance of a magnetizing current and magnetic flow in the transformer core. For this reason, an emf will be induced in the other windings of transformer Tpl. The phases of positive feedback windings 7-6 and 6-5 are so chosen that that triode, whose collector current is greater, will receive the negative bias on its base and open completely. At the same time, positive bias will be fed to the base of the other triode and it will close completely. The increase in the collector current of the open triode ceases when the triode is saturated. At this point, the emf in the windings of transformer Tpl decreases, leading to a decrease in the current in the base circuit and collector current of the open triode. As a result, the phase of the emf changes by 180°, positive bias is fed to the base of the first triode and it closes, while negative bias reaches the base of the second triode and it opens. The subsequent operation of the circuit continues in a manner similar to that described above.

In order to provide reliable self-excitation of the circuit when the power supply is connected, resistor R2 is shunted by high-value capacitor C1. At the moment the power supply is connected, because of the charging current of capacitor C1, heavy bias is created on resistor R1, causing an increase in the initial collector current of the triodes, and thus facilitating self-excitation of the circuit. In addition, capacitor C1, compensating the inductive magnetizing current of transformer Tpl, improves the triode collector current wave form.

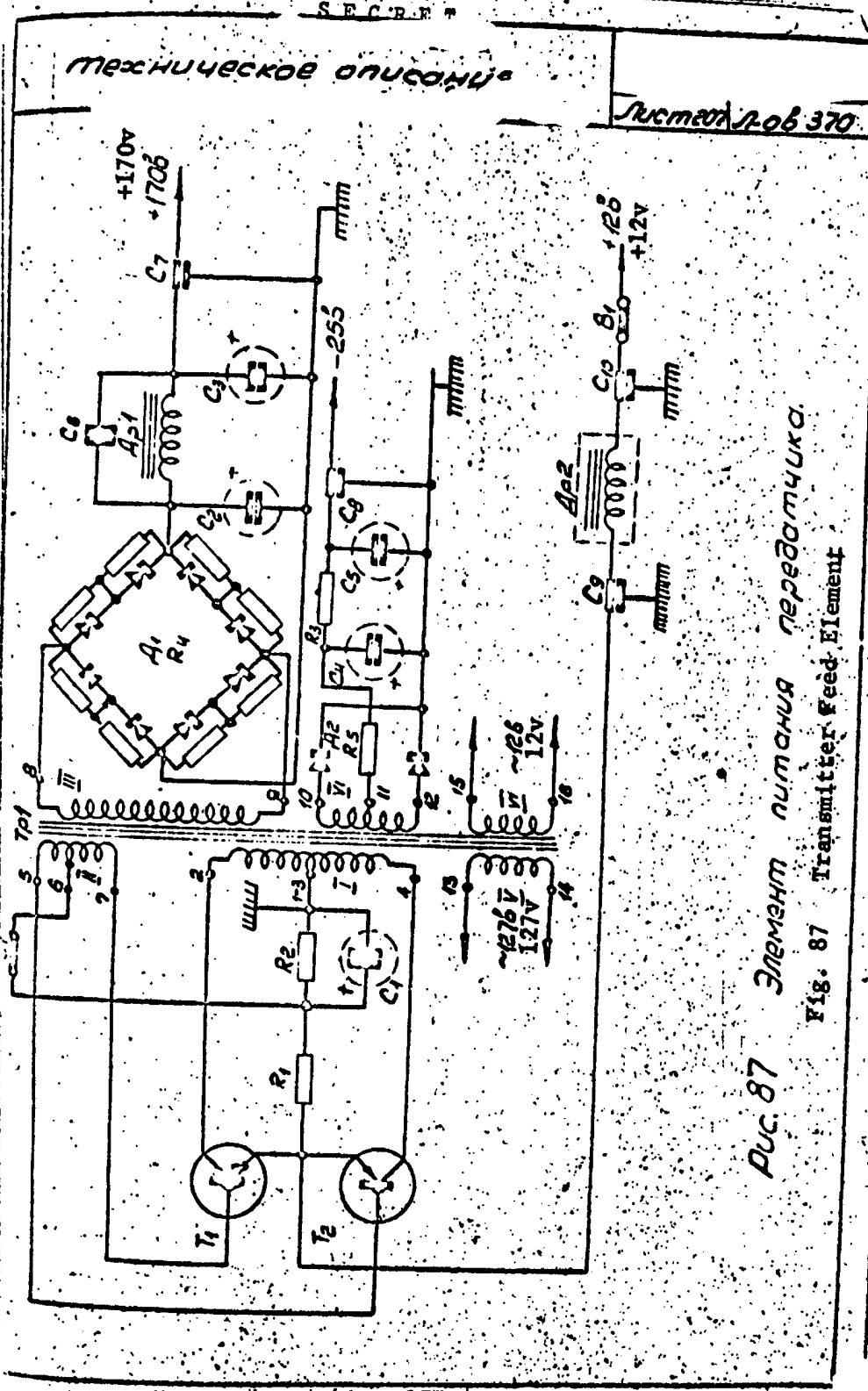


Рис. 87 Элемент питания передатчика.
Fig. 87 Transmitter Feed Element

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S-E-C-R-E-T

In the feed elements of the transmitter and receiver the converted a-c voltage, tapped from the secondary winding III of transformer Tpl, is rectified by germanium diodes $\Delta 1$ which are mounted in a bridge circuit. Smoothing filter C2-pl-C3-C6 is located in the circuit of the rectified voltage.

The converted a-c voltage, tapped from winding IV of transformer Tpl, is rectified by germanium diodes $\Delta 2$ which operate in a full-wave rectifier circuit. Smoothing filter C4-R3-C5 is located in the rectified voltage circuit.

In the feed element of the line circuits the converted a-c voltage, tapped from windings III and IV of transformer Tpl, is rectified by germanium diodes 1 and 2 operating as full-wave rectifiers. Smoothing filters C2-R3-C3 and C4-R4-C5 are located in the rectified voltage circuits.

When operating from the a-c mains, the $\pm 12v$ voltage is not fed to the feed elements, and the feedback circuit for the self-excitation of triodes T1 and T2 is broken; that is, contacts A and B of adapter block 1 (2 or 3) are broken by means of the corresponding switches. The feed elements operate on a 127-v alternating current. This voltage is fed to line winding V of transformer Tpl. The line winding is so designed that the values of the rectified voltages at the feed element output are identical, both in the case of storage battery power supply as well as a-c mains power supply. The filament circuits of all the tubes of the corresponding devices, in the case of mains power supply, are also fed with the a-c voltage tapped from secondary winding VI of transformer Tpl.

The d-c voltage of the storage batteries is converted into a-c voltage in the feed element of the power amplifier section by means of a crystal triode converter. The operation of the converter circuit in the power amplifier is similar to that described above for the circuits of the feed element converters of the receiver, transmitter and line circuits.

For improved temperature conditions in the operation of the circuit, the bodies of the crystal triodes are connected to a copper plate.

The a-c voltage, tapped from secondary windings 6-8 and 9-10 of transformer Tpl, is rectified by germanium diodes $\Delta 2$ and $\Delta 3$ mounted in the bridge circuit (Fig. 88). Present in all the circuits of the rectified voltage are smoothing filters C17-pl-C15 and C18. Choke Π pl-C16 is a wavetrap tuned to a pulse frequency of 100 cycles.

The voltage for the screen grid of tube $\mathcal{N}1$ is tapped from midpoint 7 of winding 6-8 of transformer Tpl and fed to the tube through smoothing filter C19-P9-C20.

When power is derived from the a-c mains, the $+12v$ voltage is not fed to contact 2 of the winding of transformer Tpl. The power converter operates on alternating current with a voltage of 127v. This voltage is fed to line winding 4-5 of transformer Tpl. The line winding is so designed that the values of the rectified voltages at the output are identical both in the case of storage battery and mains power.

The filament voltage for tube $\mathcal{N}1$ in the case of mains power is tapped from winding 14-15 of transformer Tpl.

The fundamental electrical characteristics of the converter elements are given in Appendix 4.

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Mains Board

The mains board is designed in the form of a rectangular welded case with ventilation apertures in the rear and side walls and with an inclined forward panel (Fig. 89).

Located within the case is an autotransformer, the control for which has been remoted to a position above the board. Located on the rear wall of the case are plugs for connecting cables $\mathcal{W}1$, $\mathcal{W}2$, $\mathcal{W}10$, $\mathcal{W}14$, $\mathcal{W}20$ and a grounding terminal.

The arrangement of the forward panel of the mains board may be seen in Fig. 89. Transformer Tp2 is located behind the main frame of the board along a wooden base.

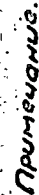
The mains board measures 230 X 320 X 397 mm and weighs not more than 22 kg.

The basic diagram of the mains board is given in Fig. 90. From the input recess (van port) the power from the a-c mains is fed over cable 10 to contacts 1-2 of plug $\mathcal{W}10$. Contact 2 of this plug is connected with contact 4 of the winding of autotransformer Tp1 through the contacts of mains "on-off" switch B1 (BWX.-CETb)* and fuse $\Pi p.1$ (type PTsP-10). Contact 1 of plug $\mathcal{W}10$ is connected with termination 2 (in the case of a mains voltage of 220v) or with termination 3 (in the case of a mains voltage of 127v) through the contacts of mains "on-off" switch B1 and those of switch B2.

The 127v a-c voltage for all the feed elements of the station and transformer Tp2 is tapped from fixed contact 4 and movable contact 5. The end of winding I is a common mains wire (mains 1) which runs to contact 7 of plugs $\mathcal{W}1$ and $\mathcal{W}2$ for powering the frames. This same wire is fed through fuse $\Pi p2$ (127v - 1A) to contact 2 of plug $\mathcal{W}14$ for powering the power amplification section and directly to contact 2 of plug $\mathcal{W}20$. This plug is designed for the connection of a second power amplification section (for a second half-set), if the station is equipped with one. Termination 5 of the winding is fed: through fuses $\Pi p3$ (PER-K), $\Pi p4$ (PR-K) and $\Pi p5$ (LTs), respectively, to contacts 6, 5 and 4 of plug $\mathcal{W}1$ for powering the feed elements of the transmitter, receiver and line circuits of half-set A; through fuses $\Pi p6$, $\Pi p7$ and $\Pi p8$, respectively, to contacts 6, 5 and 4 of plug $\mathcal{W}2$ for powering like components of half-set B. From contacts 4 and 5 of the winding of the line transformer the 127v a-c voltage is fed to the jacks of block TH2, which is used to connect test equipment, and also to the mains board transformer.

Connected in parallel, through resistors R2-R8, to the above listed fuses are neon lamps H 2-H 3 (type MN5), which light in the event the corresponding fuse fails.

The autotransformer of the mains board makes it possible to maintain a station feed voltage of 127 volts despite voltage fluctuation of 20% or +10%. The voltage is monitored by a type-M5-2 d-c indicator device. The rectified voltage is fed to the indicator from rectifier bridge 3 using selenium rectifiers type AVS-15-12. Resistors R11 and R12 are used to calibrate the readings of the indicator.



Note: In one branch of.

bridge A2 are 5-bar met. sealed diodes, each of which is shunted by a resistance.

Рис. 88. Схема преобразователя электропитания усилителя мощности, shunted by a resistance.

Fig. 88 Power Conversion Diagram of Power Amplifier

Place Purp. of Circ. Cont. No. *W-10*

Кудряшова	Назнич Черн	№ 3
Акс	Общ Comm.	3
Акс	4128 + 124	12

(see above table)

Классификация	Наименование	№ п/п
УЧУД-19/	Сем 127	1
УЧУД-19/2	Сем 127	2

mains 127

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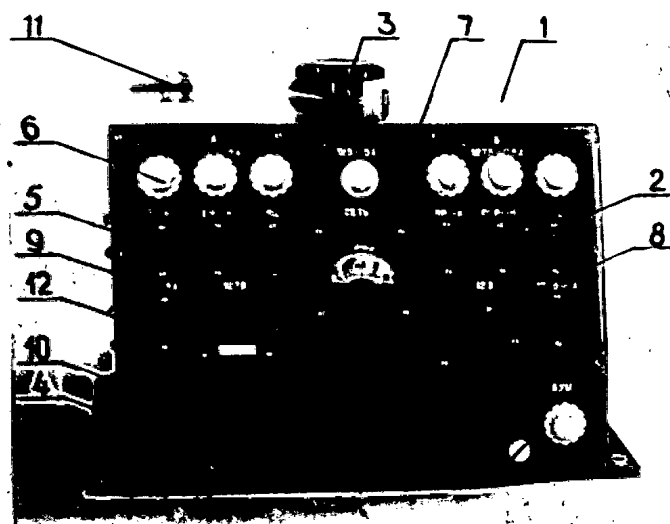
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FIG. 89 - Mains Board

- | | |
|----------------------------|-------------------------------------|
| 1. Case | 7. Indicator Device |
| 2. Forward Panel | 8. Adapter Block with |
| 3. Autotransformer Control | 12v a-c Voltage (ϵH_1) |
| 4. Mains Switch (B_1) | 9. Adapter Block with |
| 5. Fuses | 127v a-c Voltage (ϵH_2) |
| 6. Signal Lamps | 10. Cover of Fuses Type PTsL-10 |
| | 11. Switch Limiter |
| | 12. Identification Shield |

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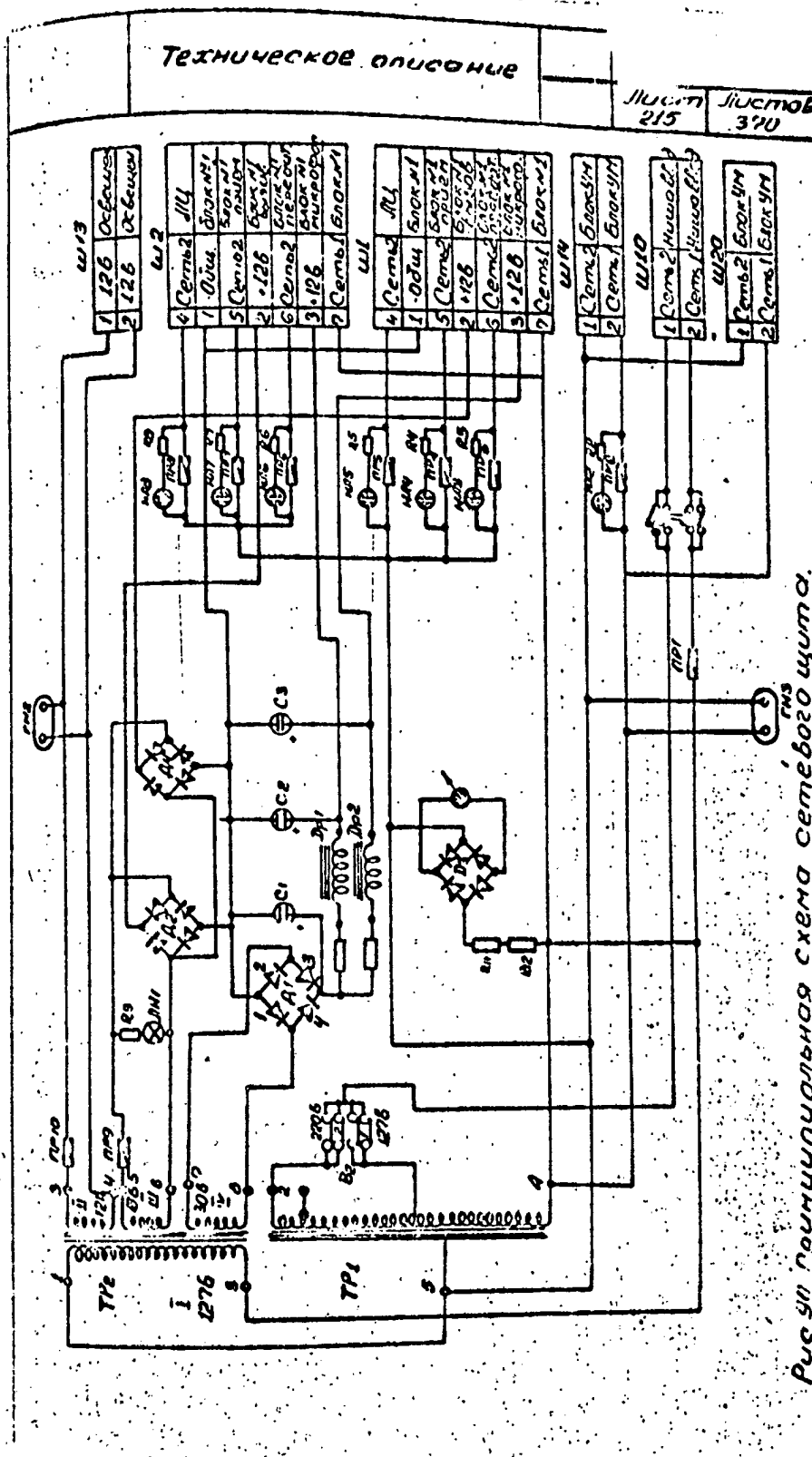


Рис. 90 Принципиальная схема сетевого щита.

Fig. 90 Basic Diagram of Mains board

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Winding III of the transformer serves to feed rectifiers $\Delta 2$ and $\Delta 4$ which are set up in a bridge circuit using selenium rectifiers type AVS-40-46. Present in the coil winding is fuse $\Pi p9$ (12v-3a) and signal lamp $\mathcal{L}H1$ (13v-0-18a) connected through resistor R9. This lamp indicates the presence of a-c mains current in the station. It flashes when the mains are connected by on-off switch B1 and goes out when there is no mains voltage at the input recess or in the event fuses $\Pi p9$ and $\Pi p1$ burn out.

The negative rectified voltage is fed from rectifiers $\Delta 2$ and $\Delta 4$ to contact 1 (a common contact) of plugs $\mathcal{W}1$ and $\mathcal{W}2$. The positive rectified voltage (12v) is fed from rectifier $\Delta 4$ and $\Delta 2$ to contacts 2 of plugs $\mathcal{W}1$ and $\mathcal{W}2$ to power the pole changer, ringing system relay and bell of the corresponding half-sets.

The 12v alternating current for van illumination is fed from winding II of the transformer through contacts 1 and 2 of plug $\mathcal{W}13$. From the same winding the 12v a-c voltage is transmitted to the jacks of block $\Gamma H2$ which is used to connect a soldering iron or portable lamp. Fuse $\Pi p10$ (type PTsP-10) is located in the coil circuit.

Connected to coil IV of the transformer is rectifier $\Delta 1$ used to power the microphone circuits of the speak-buzz unit, the telephone channel limiters and the suppressor grid of the transmitter output tube. Connected to the rectified voltage circuit (12v) are smoothing filters consisting of resistors R10 and R13, chokes $\Delta p1$ and $\Delta p2$ and electrolytic capacitors C1, C2 and C3. The negative rectified voltage is fed to contacts 1 (common contacts) and the positive to contacts 3 of plugs $\mathcal{W}1$ and $\mathcal{W}2$.

Charging Board

Each equipment half-set is provided with a charging board.

The charging board is designed in the form of a rectangular metal case (Figs. 91 and 92). Fastened to the front panel are the basic units of the board: 30v-voltmeter, 30a-ammeter, their switches, a type-AZS-10 cut-off switch for the power supply of the equipment and power amplification section, switches for the storage battery groups $\text{PA3P}\mathcal{A}\mathcal{A} - \text{B}\mathcal{M}\mathcal{K}\mathcal{I} - 3\text{AP}\mathcal{A}\mathcal{A}$ ("DISCHARGE-OFF-CHARGE"), the switch for the charging generators $\text{A}\mathcal{P} - \text{B}\mathcal{M}\mathcal{K}\mathcal{I} - \mathcal{F}\mathcal{E}\mathcal{H}$ ("CHARGER-OFF-GENERATOR"), the 12v d-c voltage block for connecting a soldering iron or portable lamp and a reverse current relay.

Attached to the lower wall of the charging board are plugs for connecting cables $\mathcal{W}-3$, $\mathcal{W}-8$, $\mathcal{W}-9$, $\mathcal{W}-11$, $\mathcal{W}-15$, $\mathcal{W}-17$, $\mathcal{W}-16$. The rear cover may be removed and is fastened to the board by means of screws.

The charging board measures 305 X 251 X 123.5 mm and weighs not more than 6 kg.

The charging board is designed to operate with two types of battery chargers: the PES-0.75 and AB-1-P/30.

The charging board makes possible the following operations:

- connection of a battery charger or power take-off system for charging of the storage battery groups;

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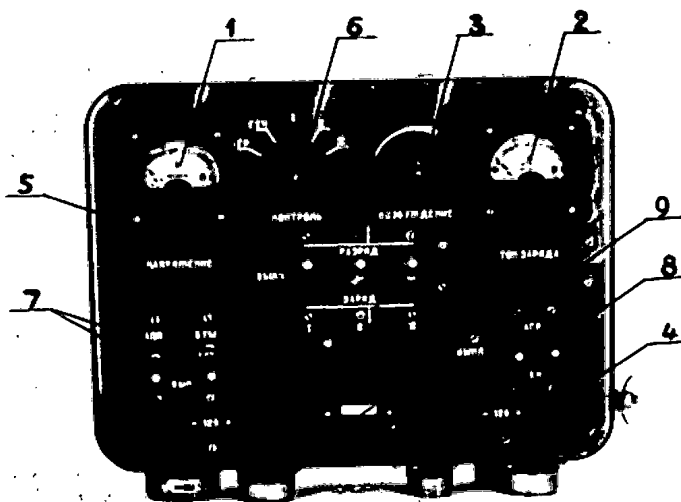


FIG. 91 - Charging Board

1. Voltmeter
2. Ammeter
3. Rheostat for Exciting the Generator of the PES-0.75 Battery Charger (P_5)
4. 12v d-c Jack
5. Battery Group Switches (B_1, B_2, B_3)
6. Ammeter-Voltmeter Switch (B_4)
7. Type AZS-10 Switches (B_6, B_7)
8. Battery Charger Switch (B_5)
9. Identification Shield

ТЕХНИЧЕСКОЕ ОПИСАНИЕ

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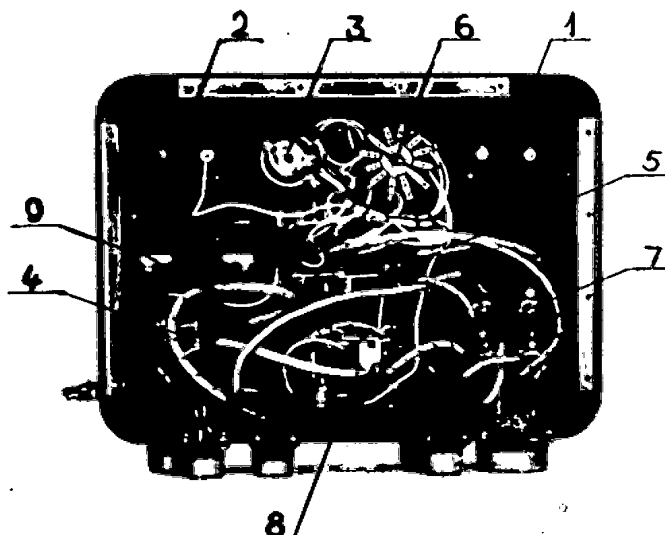


FIG. 92 - Rear View of Charging Board with Cover Removed

1. Voltmeter
2. Ammeter
3. Rheostat for Exciting Generator of PES-0.75
Battery Charger
4. Battery Charger Switch
5. Battery Group Switches
6. Ammeter-Voltmeter Switch
7. Type AZS-10 Switches
8. Reverse Current Relay
9. Ammeter Shunts

E-
 E2
 D2
 C
 B
 A



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- switching of any storage battery group to "CHARGE-DISCHARGE" or "OFF";
- regulation and monitoring of the total charging current of the storage battery groups when charging from a PES-0.75 charger;
- monitoring of the voltage of the storage battery groups.

A basic diagram of the charging board is given in Fig. 93.

The charging circuit for the storage battery group is formed as follows: contacts 8-12-13 (4-5-9 or 10-14-15)* of plug $\mathbb{W}$ -8, left-hand contacts of switch B1 (B2-B3). Subsequently, the charging circuit branches off: through switch B6 the power supply is fed to the rack through contacts 1-2 of plug $\mathbb{W}$ -3; for van illumination through contacts 1-2 of plug $\mathbb{W}$ -17 and two jacks of blocks FH3 and FH4; through switch B7 and contacts 1-2 of plug $\mathbb{W}$ -16 to the power amplification section.

The power supply for the power amplification section may also be taken from the second charging board through contact 4 of plug $\mathbb{W}$ -11.

The minus of the storage batteries of all groups is connected through contacts 1-2-3-6-7 of plug $\mathbb{W}$ -8 with the grounding busbar of the charging board (common).

The charging circuit of the storage battery groups from the battery charger is formed as follows: contacts 1-3 of plug $\mathbb{W}$ -9, the current winding of reverse current relay P, the contacts of this relay, the left-hand contacts of switch B5, the shunt of ammeter R1 (R2 or R3), the right-hand contacts of switch B1 (B2 or B3) and contacts 8-12-13 (4-5-9 or 10-14-15) of plug $\mathbb{W}$ -8. The circuit of the voltage winding of reverse current relay P is formed as follows: contacts 1-3 of plug $\mathbb{W}$ -9, the voltage winding, resistor R4 and contact 4 of plug $\mathbb{W}$ -9.

The excitation circuit of generator GSK-1500 of battery charger PES-0.75 is formed as follows: contacts 1-3 of plug $\mathbb{W}$ -9, driving current adjusting rheostat R5 and contact 2 of plug $\mathbb{W}$ -9.

The excitation of generator GAB-1-P/30 of battery charger AB-1-P/30 is adjusted by means of the rheostat located on the control panel of the charger.

The charging circuit of the storage battery groups from the generator of a power system is formed in the following way: contacts 1-2-3 of plug $\mathbb{W}$ -15, the right-hand contacts of switch B5, the shunt of ammeter R1 (R2 or R3) and further, as in the case of charging from a battery charger.

The charging circuit of both charging boards of the station are interconnected by means of cable $\mathbb{W}$ -11 (contacts 1-3).

* The designation of the corresponding units for the charging circuits of the second and third battery groups are given in the parentheses.

When charging the battery groups of different half-sets from a single PES-0.75 charger, the GSK-1500 generator excitation current is adjusted at that charging board to which the battery charger is connected, with reverse current relay P of this board playing no part in the operation.

Type AZS-10 cut-off switches B6 and B7 for the power supply of the station equipment and power amplification section are provided with thermocontacts, because of which they automatically disconnect the power supply if the current consumed exceeds 10 amperes.

Battery Charger

A station equipment set includes two electric battery chargers type PES-0.75 or AB-1-P/30. The PES-0.75 electric battery charger consists of a single-cylinder two-cycle motor type 2SDV and GSK-1500 four-pole d-c shunt generator (Fig. 94).

Battery charger AB-1-P/30 consists of the same 2SDV motor and a type GAB-1-P/30 four-pole d-c compound generator.

Charger Characteristics	PES-0.75	AB-1-P/30
Rated engine power	2 HP	2 HP
Operational output of charger	575 watts	1 kilowatt
Rated current	23 amp	33.3 amp
Rated voltage	25v	30v
Engine revolutions at operational output	3000 rpm	3000 rpm

A detailed description of the design and operation of the individual parts of the engine and electric charger is given in the technical documentation accompanying the battery charger, and provided by the manufacturing plant.

Power Take-Off System

The storage batteries of the R-401M may be charged, both when parked as well as when in motion, by means of a power take-off system from the truck engine.

The power take-off system from the truck engine consists of a power take-off box, generator actuator, type G-74 d-c generator, type RRT-31 regulator relay and a type FG-57 AB noise-suppression filter.

The power take-off box is installed to the right of the truck gearbox. It consists of a driven gear, a gear which slides over a slotted shaft, an intermediate gear rigidly connected to the slotted shaft and a drive shaft with a gear. The driven gear is constantly coupled with that of the shaft of the truck gearbox. The gear sliding over the slotted shaft can engage or disengage the driven gear by means of a forked lever and forked coupling rod. The lever handle is extended into the truck cabin. The intermediate gear is constantly coupled with the drive shaft gear.

The generator actuator consists of a pulley with pipe union fixed to the drive shaft of the power take-off box, a V-belt drive, a pulley attached to the generator shaft and a roller fastened to a spar and used for tightening the belts. V-belts 17 X 10 X 1130 mm (GOST 5813-51) are used in the belt drive.

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Generator G-74 is installed in the driver's cabin so that its pulley is located to the right of the gearbox.

The basic electrical characteristics of the G-74 generator under operating conditions are:

- output - 2 kilowatts;
- voltage - 17 volts;
- current - 108 amperes;
- revolutions per minutes in protracted operation - 3500 rpm.

The G-74 generator is designed to operate jointly with an RRT-31 regulator relay over a single-wire circuit with negative grounding. The RRT-31 regulator relay is used to maintain a constant voltage (17v), limit the current and protect the generator against reverse current should the rate of revolution of the generator change.

A type FG-57AB noise-suppression filter is installed for noise suppression in the charging circuit of the storage batteries. The output terminals of the generator regulator relay and filter have also been shielded. The generator voltage is fed from the output of the noise-suppression filter to both charging boards by means of cables U-15. Regulator relay RRT-31 and noise-suppression filter FG-57AB are located on a bench in the right front corner of the van.

During operation the charging voltage at the regulator relay output can be adjusted within small limits by a variable resistor, the control for which has been remoted to the side wall of the RRT-31 regulator relay itself.

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CHAPTER III

OPERATION OF THE STATION

1.

Location of the Station on the Terrain

It should always be borne in mind that the range of communication, its stability and quality, are determined to a great degree by the aptness of choice when selecting the site for the station.

When selecting a site for a station in a given area, the following fundamental factors must be considered:

- the terrain relief and location of local objects;
- proximity of the site to other radio and radio relay stations;
- proximity of the site to sources of industrial interference;
- possibility of access to, and removal of, the equipment;
- provision for concealment and camouflage.

The terminal stations of radio links should be located as close as possible to the telephone and telegraph stations of the communications center. This results in reduced expenditures of wire communication facilities for connecting lines. Such wire connecting lines, despite their relatively small length when compared with that of the radio link itself, constitute an important factor, determining to a significant degree the stability and operational reliability of the entire radio link. The shorter such connecting lines, the more rapidly communication can be established and the greater the assurance that it will be of good quality and high reliability.

It is true, however, that for purposes of increased concealment of command points, and also because of the specific conditions imposed by the possible utilization of atomic weapons, terminal stations should be removed from the communication center by 2-3 km, and occasionally at even greater distances. Stations should also be situated at a certain distance from the communication center in the event that the presence of considerable interference to reception is detected and when local terrain features or relief have a particularly obstructing effect on the routing of the line. It is, in this connection, important to bear in mind that the permissible attenuation for wire communication lines of telephone channels, together with the attenuation in the components of the distributing frame, constitutes 1.0 nepers in each direction of the link.

Under conditions characteristic of wooded terrain of average relief and in steppe regions, the proper selection of station sites, in order to provide a range of up to 45 km when working on antennas raised to their full mast height, does not require a preliminary survey of the route. In these conditions, communication will be stable with midpoint obstructions of 50-75m between the antennas of the

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terminal stations. However, it should be borne in mind that a preliminary and accurate survey of the route of the proposed radio link may well result in considerably enhanced communication stability and increased range.

On open routes communication is possible at distances of 70-100 km in a single interval. This fact makes it possible in certain instances to operate without intermediate stations or to reduce their number, provided that terrain conditions and the tactical situation permits the selection of open routes. On open routes, on routes with low midpoint obstructions and also on short routes, it is possible to operate with reduced antenna height. This provides greater concealment, complicates jamming by the enemy and facilitates camouflaging of the station.

Use of the antenna at less than its complete height requires considerably less time and thus results in enhanced communication operability. However, it should be remembered that on obstructed routes lowered antenna height may lead to impaired communication or even to complete loss of the signal. For this reason, in order to provide reliable communication when operating over lowered antennas, a preliminary survey of the route is essential. The selection of radio link routes is made on the basis of topographic maps. The methodology employed in making this selection is described in the following section.

Of particular importance is the selection of open routes or routes having low midpoint obstruction for a link consisting of several intervals, when the number of intermediate stations is more than two. Despite the satisfactory or even good quality of communication over the individual intervals of a radio relay line, communication over the entire line may be unstable, with high noise levels in the telephone channels. Such a situation derives from the fact that the noise power at the output of the link is represented by the sum of the noise levels of the individual component intervals.

Under mountain conditions communication is possible, not only over open routes, but also over routes obstructed by mountain ranges. In the latter case the stations are to be removed from the foot of the mountain obstructing the link, in such wise as to provide, if possible, direct line-of-sight between the peak of the mountain and the station. Fig. 97 shows a mountain route in which reliable communication was provided despite a midpoint obstruction in the order of 450 meters in height.

The presence of an electromagnetic field beyond the range of direct line-of-sight is the result of the phenomenon of radio wave refraction and the ability of such waves to bend around obstacles. The screening effect of obstacles depends on their position on the route of the line.

Steeply sloped elevated areas, woods, high mounds, stone and reinforced concrete buildings, metal structures, transverse running communication and power lines located on the route, will exert a screening effect, the magnitude of which is a direct function of their proximity to the antenna. It is important, for this reason, to select for the station a site which provides a good view toward the opposite station. At the same time, the screening effect of the terrain should be exploited to maximize the difficulty of monitoring and jamming by the enemy.

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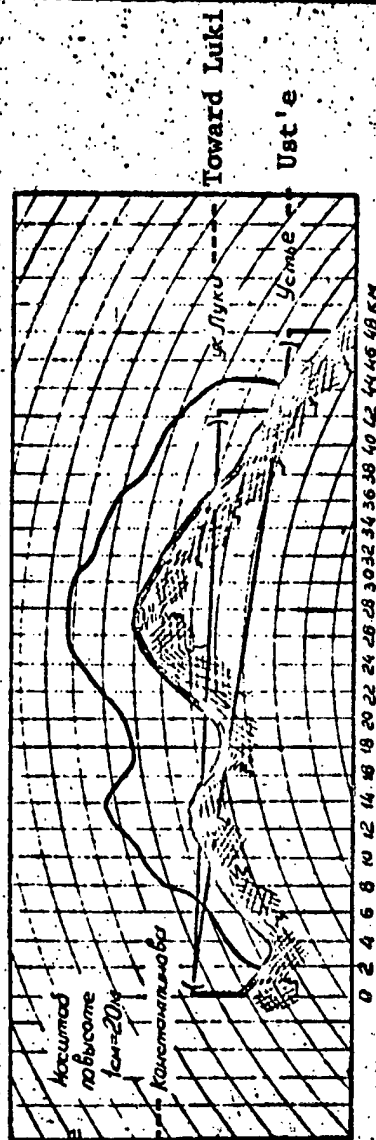


рис. 95

Трасса с закрытием 50-70 м.

Fig. 95 Route with 50 - 70 Meter Obstruction

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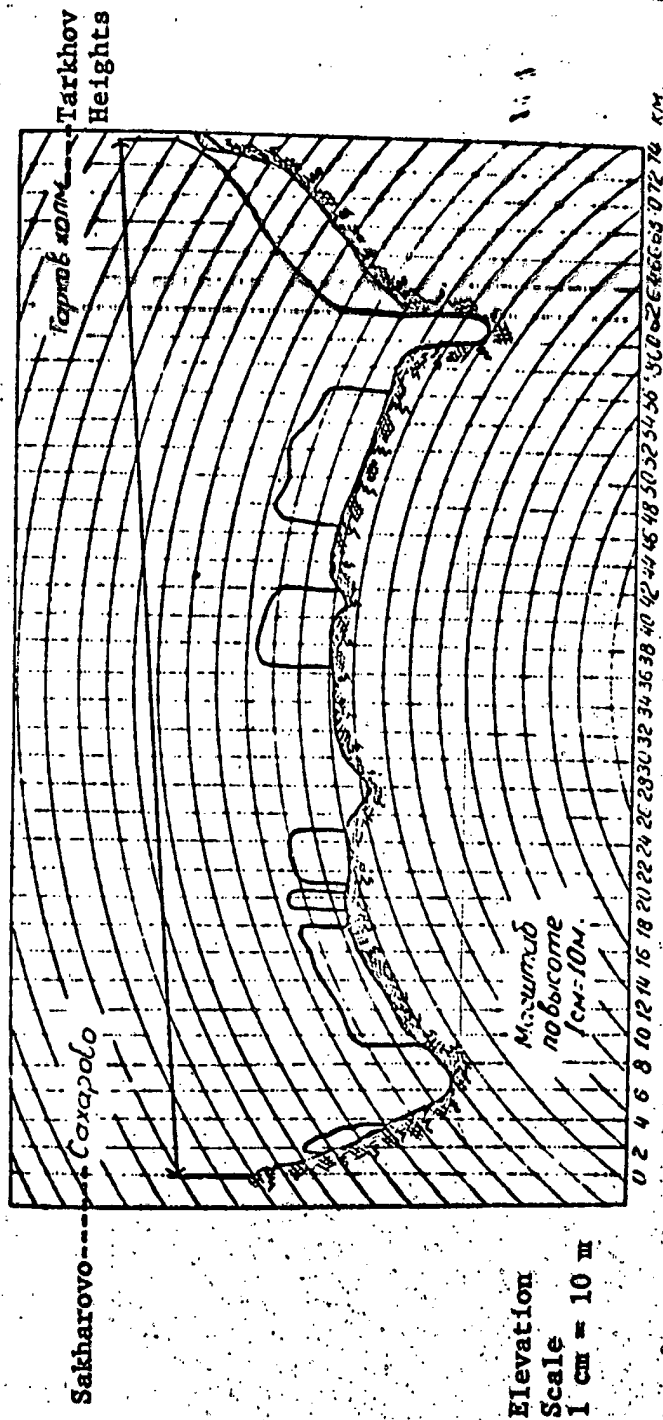


Рис. 96 Открытая трасса

Fig. 96 Open (Unobstructed) Route

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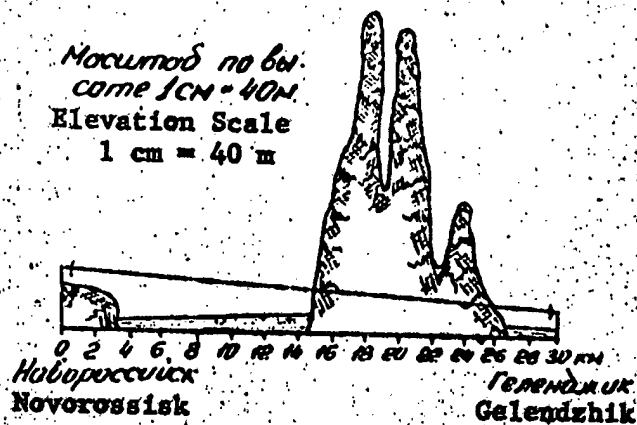


Рис 97

Горная трасса

Fig. 97 Mountain Route

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The level of the electromagnetic field beyond obstacles does not remain constant in time. It depends on the condition of the weather, the time of day and the season of the year. Maximum field level (highest quality of communication) occurs at night and in the early morning and decreases during daytime hours. The sharpest change in the field is observed during the summer. In the summer period the field intensity during the space of twenty-four hours may change as many as ten times. This is caused by the fact that meteorological conditions (temperature, pressure, humidity and other factors which influence the dielectric permeability of the air) vary with time. It is this last factor (viz, the dielectric permeability of the air) which influences the ability of the waves to circumvent obstacles standing in the path of their propagation. These circumstances are to be considered when establishing a communication link and selecting station sites.

Excellent communication is possible at night over lowered antennas located in the near vicinity of obstacles. However, during the day, communication may be impossible over the very same routes if there is not a satisfactory field level margin. In such cases the antennas must either be raised to a greater height or withdrawn to a greater distance from the shielding obstacles.

Impaired communication over a radio link may also be the result of nearby radio relay stations or stations operating in the HF or UHF bands. With a concentration of several radio relay stations at a single control point, reduction of mutual interference requires that these stations be spaced at a distance of 200-300 meters one from the other. If there are more than four stations, two or three station groups should be formed. The distance between station groups should not be less than 800-1000m, and between the individual stations within each group not less than 200m. Particular attention should be directed in this connection at the correct positioning of the antennas. The area allocated to the erection of one antenna for a station should measure approximately 15 X 15m, and for two antennas - 30 X 15m. The distance between antennas of adjacent half-sets should be 16-20m, and the distance from the masts to the station van should be approximately 8-10m.

Examples showing the arrangement of antennas are given in Fig. 98.

When several stations are concentrated at a single point, the site for their deployment should be selected so as to exclude any intersection of communication directions. Should the situation change, it may be found that the formerly selected deployment of the station no longer satisfies the recommendation given above. In this case it is advisable, in order to avoid the possible occurrence of mutual interference, to change the direction of communication of the individual stations.

Communication quality over a radio link is greatly influenced by HF and UHF transmitters if the harmonics of their signal coincide with the frequency to which the receivers of the radio relay stations are tuned. If the radio relay station is located in the immediate vicinity of such transmitters, in addition to interference on the harmonics, there will also be interference from the intermodulation products and from other causes.

In order to avoid interference from HF and UHF transmitters, radio relay stations should be located at a distance of not less than 500-1000m from such transmitters and their fixed frequencies should be allocated with a view toward the frequencies assigned to the HF and UHF transmitters.

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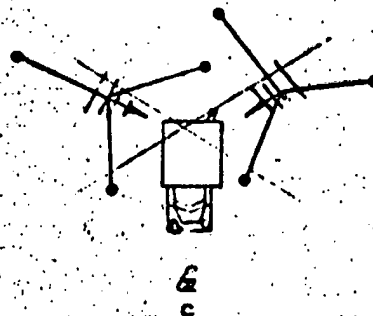
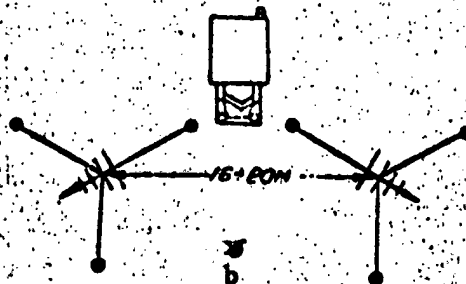
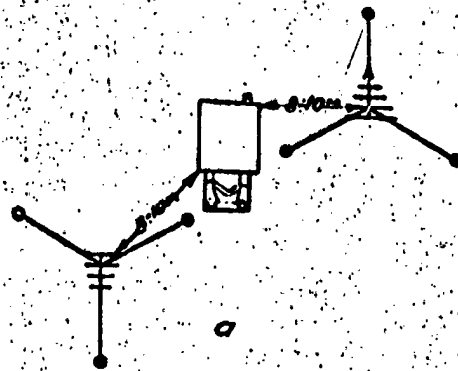


Рис 98. Примеры правильного и неправильного расположения антенн:
 а, б. Правильное расположение антенн.
 в. Неправильное расположение антенн.

Fig. 98 Examples of the Correct and Incorrect Arrangement of Antennas

a) and b) - correct; c) - incorrect

In order to avoid the effect of industrial interference, which may considerably impair the quality of communication, stations should be located no nearer than 300-500 meters from highways, industrial enterprises, garages, electrified railroads, high-voltage power lines, etc.

The possible use of atomic weapons requires that particular attention be given the correct deployment of the station on the terrain. Under these conditions measures must be taken directed at more careful engineering and camouflaging of the station site.

The vehicle of the station should, as a rule, be located in a trench-type concealment with a ramp. The depth of the trench should be 0.5m greater than the height of the truck van. The stores of fuel and lubricants should be placed 20-25m away from the ditch in special open pits (fissures).

If necessary the equipment of the station may be removed from the van and placed in bunkers.

In a combat situation, when there is insufficient time to erect shelters and bunkers, radio relay stations may be set up for communication purposes outside the protective areas, in which case, of course, exploitation of the natural defensive features of the area is obligatory. Included among such natural and local shelters, and therefore to be widely used, are hollows, depressions, ditches, various underground areas and structures, the cellars of buildings, etc.

2.

Selecting the Route of the Radio Link

The route of the radio link is selected on the basis of topographic charts drawn to a scale of 1:50,000 or 1:100,000. The chart phase of the operation consists of an evaluation of the terrain and the laying out of the link in intervals. The selection of the station sites is made in accordance with the requirements discussed in the preceeding section.

The following sequence of operations may be recommended when choosing a radio link route.

A notation is made on the map of the station sites and the points of highest elevation on the terrain (Fig. 100).

In Fig. 100 the terminal stations are set up at points A and 5, and the intermediate station at point B.

An approximate method of evaluating the route consists in comparing the half-sum of the elevations of points A and 5 (considering the height of the antenna mast) with the sum of the highest elevation B, lying on the route between points A and , and the height of the curvature arc of the earth's surface corresponding to the given distance between points A and 5.

If the first half-sum is greater than the second sum, then in the first approximation the route may be considered open. Otherwise the route will be obstructed. The excess of the first value over the second characterizes the degree of obstruction on the route.

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The elevation of the arc of the earth's curvature may be determined by the approximate formula: $H = \frac{R^2}{50}$,

where: R is the distance in kilometers,

H is the elevation of the arc of the earth's curvature in meters.

Let us determine, by way of example, the presence of direct line-of-sight between the antennas of stations located at points A and B (Fig. 100). The distance between points A and B, determined by the chart, is $R_1 = 50$ km. We will assume that the height of the antenna supports at both stations is 14m. In this case the elevation of the antenna above sea level at point A will be $174.2 + 14.0 = 188.2$, and at point B will be $160 + 14.0 = 174$ m.

The elevation of the arc of the earth's curvature equals: $H = \frac{50 \times 50}{50} = 50$ m.

The half-sum of the antenna elevations above sea level will equal:

$$\frac{188.2 + 174}{2} = 181.1\text{m.}$$

The sum of elevation B and the elevation of the arc of the earth's curvature is $160 + 50 = 210$.

From a comparison of the values found (the half-sum of the antenna elevations above sea level and the sum of the greatest elevation on the route and the elevation of the arc) we see that the first value is less than the second. Consequently, this route is obstructed.

From the example given, it is clear that the obstruction present in interval A-B (Fig. 100) is $210 - 181.1 = 28.9$ m. Thus, there will be stable communication over this interval.

Through similar computation it is not difficult to see that over the interval B-C (Fig. 100) the route will be open.

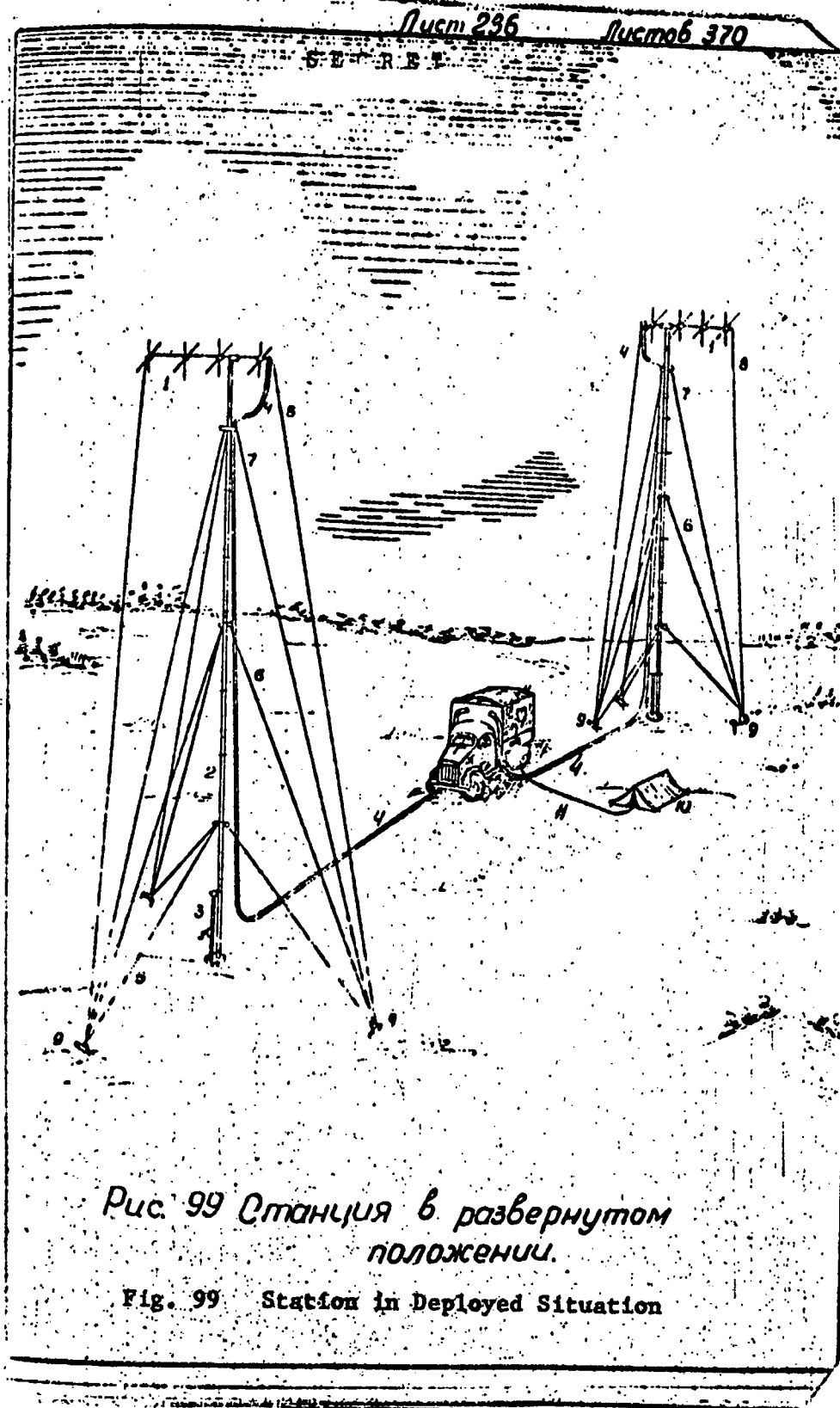
For a more precise determination of the profile of the route it is necessary to plot the arc of the earth's surface and to enter all the basic elevations on the route. To plot such an arc, the elevation of the arc is determined according to the formula given above and a number of its points is calculated, according to Fig. 101, where A and B are the points of the station sites; C, D, E, F are auxiliary points.

The arc of the earth's surface is plotted according to the values obtained. All the elevations and the depressions of the terrain are taken from the map and entered in a definite scale of elevations on the arc once it has been plotted. The points plotted are connected by an even curve, as a result of which a profile of the given route is obtained (Fig. 102).

EXAMPLE: Plot the arc of the earth's curvature for an interval of 50 km, $H = 50$ m.

$$\frac{R}{6} = 8.3. \quad \frac{8H}{9} = 44\text{m,}$$

$$0.36 R = 18 \text{ km, } \frac{H}{2} = 25\text{m.}$$



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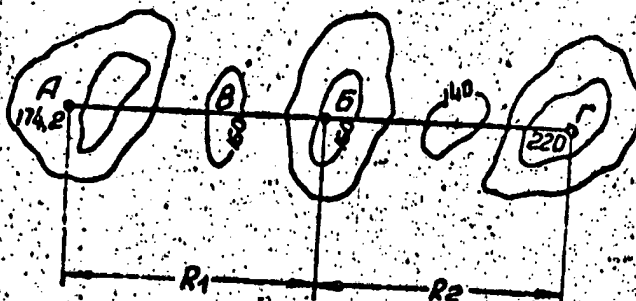


Рис. 100. Ориентировочный метод проверки
наличия прямой видимости.

Fig. 100 Approximate Method of Determining Direct
Line-of-Sight.

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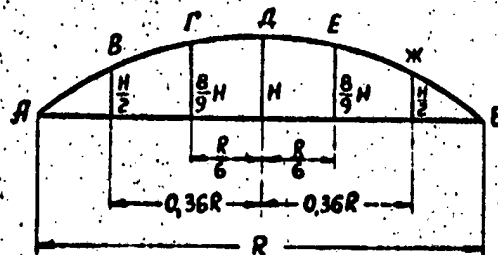


Рис. 101

Определение вспомогательных точек для
 приближенного построения дуги земной
 кривизны.

Fig. 101 Determination of Auxiliary Points
 For Approximate Plotting of Arc of Earth's
 Curvature

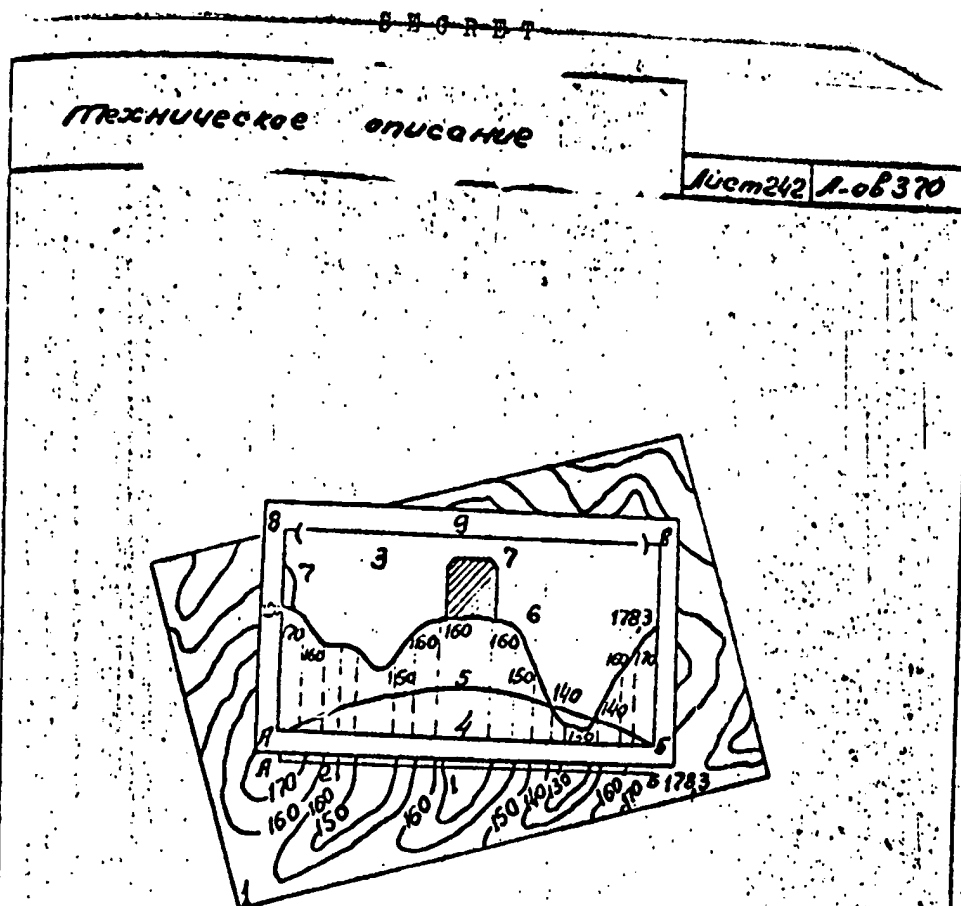


Рис. 102

Порядок вычерчивания профиля трассы при отсутствии специального бланка.

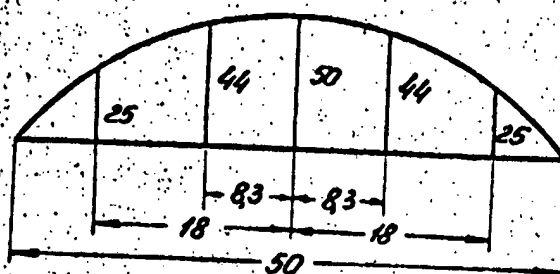
Fig. 102 Sequence for Plotting Route Profile when Special Form is Not Available

1. Топографическая карта. Topographic map
2. Прямая линия на карте, соединяющая точки установки станций / А, Б / Straight line on map connecting station sites. (A and B)
3. Чертеж профиля трассы. Route profile sketch
4. Прямая линия на чертеже, от которой строится профиль трассы. Straight line on sketch used to plot route profile.
5. Дуга земной кривизны. Arc of earth's curvature
6. Линия профиля местности. Terrain profile line
7. Лесные предметы / лес, строения / Local objects (woods, buildings)
8. Антенные опоры / в масштабе высоты / Antenna supports (to scale)
9. Линия прямой видимости. Direct line-of-sight

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Elevation Scale 1 cm = 20 m Масштаб по высоте 1 см = 20 м
 Longitudinal Scale 1 cm = 5 km Масштаб по длине 1 см = 5 км

Рис. 103 Пример вычерчивания дуги
 земной кривизны.

Fig. 103 Example of Plotting Arc of Earth's
 Curvature

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The arc of the earth's curvature, plotted according to the values found in this example, will appear as shown in Fig. 103.

If they are available, special previously prepared forms may be used, eliminating the need to plot curvature arcs on each occasion. Routes plotted on such forms are shown in Figs. 95 and 96.

A detailed discussion of the selection of the route is given in "Instructions On the Selection of A Radio Link Route and Communication Operating Frequencies".

3.

Selecting the Operating Frequencies

A problem of the greatest importance in the preparation of the basic documentation for the establishment of a radio link is the selection of the operating and reserve frequencies. If these frequencies are chosen incorrectly, the transmitter of an adjacent half-set of the same station or the transmitters of other stations located nearby may disrupt the proper operation of the receiver.

As a result of the effect on the receiver input of a strong signal from an interfering transmitter, receiver sensitivity to the useful signals of the correspondent station is lowered. In addition, at the output of the receiver there may be heard beat frequencies between the signals of the correspondent and the signal of the interfering station.

Practical experience in the operation of the station has demonstrated that HF and UHF transmitters located in the vicinity may exert a severe interfering effect on the operation of a radio link by their harmonics. Simultaneous operation of the station with HF and UHF transmitters located in the immediate vicinity is possible without mutual interference only if the working frequencies are so distributed that the harmonics of the HF and UHF transmitters do not coincide with the frequency of the radio link signal.

This circumstance must be particularly considered when the station is employed for remote control. A detailed discussion of the problem of frequency selection is contained in "Instructions on the Selection of a Radio Link Route and Communication Operating Frequencies".

4.

Setting Up and Dismantling the Station

Setting Up the Antenna-Mast Unit

All the personnel of the station participate in setting up the antenna-mast unit. The work is directed by the station chief.

Each member of the crew is assigned a special number. The chief has No. 1.

The antenna-mast unit is set up in four stages:

- selection of the site for the antenna installation;
- assembly of the mast erector;
- assembly of the antenna and installation of the erector;
- erection of the mast.

The setting up of the antenna is begun at the command of the station chief: "Begin setting up one (two) antenna(s)".

No. 1 indicates the antenna installation site. Nos. 2 and 3 remove the antenna case, the joint with the guide bushing and the tripod. No. 4 removes the rigging pack from the locker and brings it to the antenna site. No. 5 removes the erector with the wooden joint from the front of the van and brings it to the antenna site. Nos. 4 and 5 bring the mast joints to the antenna site. No. 1 removes the transmission lines from the case and runs them from the van to the mast in such a way that they do not impede the setting up of the antenna. No. 2 sets up the tripod opposite the pin on the left side of the truck at a distance of 2.5-3 meters. No. 3 removes from the case the antenna boom with the top of the mast and, fastening it with one end to the pin, places it on the tripod. No. 2 removes the dipoles from the case, places them in the locks on the directive boom and takes the boom with the dipoles to the antenna site.

- NOTE:
- a) The dipoles marked with a white stripe are placed in the vertical locks of the directive boom (these locks are marked with white paint) in accordance with the numbering system of the dipoles and boom locks.
 - b) When working with another R-401M station the dipoles marked with a red stripe are inserted in the horizontal locks.
 - c) When working with an R-401 station the dipoles without a colored stripe (that is, the khaki-colored dipoles) are inserted in the horizontal locks.
 - d) In order to seat the dipoles properly in the locks: insert the dipoles as far as the detent; turn clockwise as far as possible and pull back.

No. 1 connects the transmission line to the antenna.

NOTE: The transmission line marked white is connected to the antenna plug also marked white (vertical antenna), while the unmarked transmission line is connected to the khaki-colored antenna plug (horizontal antenna).

No. 5 removes the pegs from the pack and drives them into the ground at a distance of 8 meters from the base of the mast in the directions indicated by No. 1, extends the guys and fastens them to the ends of the pegs.

NOTE: The pegs should be driven in at an angle of 60° to the earth, inclined away from the mast.

No. 5 removes the covering from the erector and places the joint with the guide bushing on the erector. The guide bushing is to be installed coaxially to the gripping mechanism of the erector; for this purpose the wooden joint of the erector is passed through the gripping mechanism and the guide bushing. The joint with the guide bushing must engage the groove of the mast erector with its catch. No. 5 takes two mast joints and uses them to gradually raise the wooden joint, turning them until the catch falls into the groove.

Nos. 3 and 4 fix the antenna top to the wooden joint and fasten it by means of a wing nut. No. 2 fetches the sluing lines and fastens them to the antenna and the guys to the erector. No. 1 attaches the transmission lines to the mast. Nos. 2 and 5 set up the erector with the antenna in a vertical position. Nos. 3 and 4 attach the erector, stretching the guys of the first tier. No. 1 sees that the erector is vertically positioned. No. 2 inserts the flange in the lower groove of the wooden joint and fastens to the flange, by means of a crook and latch hooks, the guys of the third tier.

At the command of the station chief (No. 1): "Begin raising mast", the following operations ensue:

Nos. 3, 4 and 5 stand at the pegs and grab the guys of the second tier. No. 2 raises the antenna by two mast joints, takes the following mast joint and places it in the opening of the lower end of the joint, turning it until the catch engages the groove, places the erector socket under the lower joint of the mast and raises the mast with the antenna by two more joints. When the third metal joint (counting from above) begins to emerge from the guide bushing, No. 1 gives the command: "Fasten second tier of guys". At this order, No. 2 climbs up the rungs of the erector, inserts a flange in the groove of the third metal joint and fastens the guys of the second tier by means of a crook and latch hooks. Then, turning the handle of the winch, he raises the mast higher. As the mast is extended by a new joint, the erector socket is lowered and placed under the new joint. This procedure continues until the mast has been elevated to the required height. Nos. 3, 4 and 5 hold the guys and watch the mast, maintaining it in a vertical position as directed by No. 1.

NOTE: When the last joint of the mast is in place, the erector joint is set beneath it, but the mast is not raised.

No. 2 manually lifts the arresting mechanism by slowly turning the winch and lowers the mast as far as its detent in the plate. Then, together with No. 3, he fastens the second and third tier of guys to the pegs.

With No. 1 giving directions for straightening the mast, Nos. 3, 4 and 5 adjust the tension of the guys. Nos. 1 and 4 set the azimuth of the antenna precisely toward the correspondent station and fix the sluing lines to the pegs.

No. 2 attaches the transmission lines to the equipment according to the assigned frequencies. When connecting the transmission lines to the equipment, it is essential to remember that the antennas are tuned to different frequencies: the horizontal antenna is tuned to the frequencies of the lower half of the band (unmarked transmission line) and the vertical antenna is tuned to the frequencies of the upper half of the band (transmission line marked white).

Nos. 3 and 4 collect the remaining gear and put it back in its place. No. 5 grounds the station.

The second antenna is set up in the same manner.

NOTE: The mast should, as a rule, be extended to seven metal joints. Mast extension to eight metal joints is advisable only in the event of a high noise level in the telephone channels.

Dismantling the Antenna-Mast Unit

At the command of No. 1: "Lower the antenna", the following operations take place:

Nos. 3, 4 and 5 take their place at the pegs, slacken the guys and maintain the mast in a vertical position as the antenna descends. No. 2, turning the winch handle, slightly raises the mast in order to free the lower mast joint, removes the erector socket from the lower joint, removes the joint, turning the winch handle, and places the erector joint under the next mast joint.

After three joints have been removed, No. 2 climbs the rungs of the erector, disconnects the second tier of guys and removes the flange; then he lifts the arresting mechanism of the erector and, turning the winch, gently lowers the mast. When the lower end of the joint is at a distance of 10-15 cm from the ground, the arresting mechanism is lowered, descent ceases and the joint is removed.

No. 1 supervises the lowering of the mast and assists No. 2.

The entire mast is lowered in this manner.

After the mast has been lowered, No. 2 holds the antenna erector while Nos. 3, 4 and 5 unfasten the guys from the pegs and straighten them. Nos. 2 and 5 lower the erector to an inclined position and disconnect the first and fourth tier of guys. No. 4 rolls up the guys and packs all the gear. Nos. 2 and 3 bring the case for the antenna pack, remove the lower row of vertical dipoles, pack them in the covering with the white stripe and remove the antenna from the wooden joint. No. 5 removes the joint with the guide bushing from the erector, covers the erector and fastens it to the truck. During the dismantling operation, No. 3 supports the antenna once it has been removed from the erector. No. 2 removes the dipoles and packs them in the proper coverings. No. 1 disconnects the guys and transmission lines from the antenna and the station equipment; after disconnecting the transmission lines, he covers the plugs of the antenna and transmission lines and winds the transmission lines on the clamps. No. 3 packs the directive boom into its case after the antenna has been disassembled. Nos. 2 and 3 place the case containing the antenna and the joint with the guide bushing in the box under the van of the truck and close the box. Nos. 2 and 3 roll up the guys, remove the pegs and pack this gear. No. 5 packs the mast joints in the box under the van and removes the grounding of the vehicle. No. 4 places the rolled rigging in the right-hand locker in the truck van.

TN: ONE PAGE OF THE RUSSIAN TEXT MISSING AT THIS POINT.

NO FOREIGN DISSEM

....Charging of the storage batteries to less than 11 volts is not permitted. 50X1-HUM
Storage batteries having a voltage of 11v must be disconnected and placed on
"charge". Another battery group is connected, in this case, to power the equip-
ment.

NOTE: 1. The method of connecting the transmitter power supply is
outlined in the Subsection "Establishing the Communication"
of this Section.

2. The method of connecting the telegraph channel power supply
is outlined in Section #6 "Telegraph Channel Operation".

Connecting the A-C Mains to the Station

Before connecting the a-c mains to the station it is essential:

1. to ground the station (see Section #6, Subsection "Wire Connecting
Lines");

2. to check the mains voltage by means of instrument TG-2 or TS-20, which
is part of the station equipment;

3. to set the mains switch on the mains board in the lower position (mains
disconnected);

4. to turn the voltage control handle on the mains board as far as it will
go in a counter-clockwise direction.

The a-c mains are connected by means of mains cable H-4, present in the
station set, in the following order:

1. Connect cable H-4 to the plug of the left or right input recess (port)
marked "127/220 volts";

2. Connect cable H-4 to the a-c mains.

NOTE: 1. Precautionary safety measures are to be observed when connecting
the mains.

2. Connection of the station to an a-c net having a voltage greater
than 250 volts or to a d-c net is forbidden.

Connecting the Station with Power Supply from the A-C Mains

The station is connected in the following sequence:

1. On the mains board it is essential:

- to set the mains switch in position BKJ ("ON"); the signal lamp with the
inscription "12B-3A" in the center of the mains board should now light, signaling
the presence of the a-c mains power;

- by turning the handle of the voltage control on the mains board in a clock-
wise direction, to set the indicator needle to the center of the colored sector
(corresponding to 127 volts at the output of the mains board).

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S-E-C-R-E-T

2. On the forward panel of the transceiver section it is essential:

- to set the operating mode switch $\text{PA5-AE}\text{Ж}$ ("WORK-STANDBY") in position E ("STANDBY"),

- to readjust the station power selection switch from position $\text{BKK}\text{Ж}$ ("OFF") to position CETb ("MAINS"). In this case, as in the case of battery operation, the radio receiver and telephone channel section are connected.

Disconnecting the Station

When operating on battery power, the station is disconnected in the following sequence:

1. The power selection switch on the transceiver section is placed in position $\text{BKK}\text{Ж}$ ("OFF").

2. On the charging board:

- power switch $\text{AONAP-BKK}\text{Ж}$ ("SET-OFF") is placed in position $\text{BKK}\text{Ж}$ ("OFF");

- switch $\text{PA3P}\text{ЖA-BKK}\text{Ж-3AP}\text{ЖA}$ ("DISCHARGE-OFF-CHARGE") is placed in position $\text{BKK}\text{Ж}$ ("OFF").

When operating from the a-c mains, the station is disconnected in the following sequence:

1. The power selection switch on the transceiver section is placed in position $\text{BKK}\text{Ж}$ ("OFF").

2. On the mains board:

- the voltage control handle on the mains board is turned in a counter-clockwise direction as far as it will go;

- the mains switch on the mains board is placed in the lower position.

3. Cable H-4 is first disconnected from the mains and then from the plug of the input recess (van port) of the station.

4. The power cable is rolled up and placed in the trunk locker. If the station is temporarily disconnected, regardless of the type of power source, the power selection switches on the transceiver and telegraph channel sections are to be placed in position $\text{BKK}\text{Ж}$ ("OFF").

To disconnect the telegraph channels alone, the power selection switches on the telegraph channel section are to be placed in position $\text{BKK}\text{Ж}$ ("OFF").

Establishing the Communication

Communication is established with the station operating in the terminal mode. Before establishing communication, the position of the keys and switches on the forward panels of the half-set sections must be checked and the working frequencies of the receiver and transmitter must be adjusted.

The keys and switches on the forward panels must be in the following positions:

1. In position OKOH ("TERMINAL OPERATION"):
 - the switches TPAH3-OKOH ("THROUGH-TERMINAL") of the telephone channels;
 - the switches OAHOK-OKOH ("SINGLE CHANNEL-TERMINAL") on the telephone channel section;
 - the switches OKOH-ΠPOB-PETP ("TERMINAL-TEST-RELAY") of the telegraph channels.
2. In position BAKJ ("OFF"):
 - the power selection switches of the transceiver and telegraph channels;
 - the crystal calibrator switch;
 - the AFC switch of the receiver.
3. The operation selecting switches of both telephone channels - in position 2TØ ("TWO-WIRE TELE").
4. The station operating mode switch on the telephone channel section - in position BHTP. YHJ ("INTERNAL MULTIPLEXING").
5. The speech keys of the telephone channels and the ringing key - in the center position.
6. The left-hand switch of the indicator device on the transceiver section in position BAK. ΠEP. (monitoring of power at the transmitter output).

The working frequencies of the transmitter and receiver are set with the station in the standby mode.

Retuning Over the Band of a Working Transmitter is Forbidden

The working frequencies of the receiver and transmitter are set in the following sequence:

- station power is connected;
- switch CBET-BAKJ ("LIGHT-OFF") on the forward panel of the transceiver block is placed in position CBET ("LIGHT") and the dial illumination lamps of the receiver and transmitter are turned on*;

* With the station powered by batteries, the station power selection switch may be located in position BAKJ ("OFF"). With the station under mains power, the power selection switch must be reset to position CETb ("MAINS").

- the controls of the vernier dial mechanisms of the receiver and transmitter are turned in a counter-clockwise direction;
- by turning the handles marked **BOJHA** ("WAVE") the graduation lines with the numbers of the fixed frequencies on the receiver and transmitter dials are aligned with the visors (cross-wires) so that the vertical line on the visor and the graduation line on the dial of the receiver or transmitter coincide;
- the dials of the receiver and transmitter are fixed, by turning the locking devices as far as they will go in a clockwise direction;
- switch **CBET-BMKJ** ("LIGHT-OFF") is placed in position **BKJ** ("OFF").

In order to establish communication, proceed as follows:

1. The antenna transmission lines are to be connected to the high-frequency plugs of the receiver and transmitter according to the frequencies established. The transmission line marked white runs to the vertically polarized antennas tuned to fixed frequencies 88-154.
2. The transmitter is connected by placing switch **PA5-DEK** ("WORK-STANDBY") on the transceiver section in position **PA5** ("WORK"). After the tubes have heated for 15-20 seconds, the indicator arrow should fluctuate by 100 ± 20 divisions (colored sector).
3. The left-hand switch of the indicator device on the transceiver section is set in position **BX. JEP.** (monitoring of power at the transmitter input).
4. The speech key of the first telephone channel is set in position **P.KAH** ("RADIO CHANNEL") and in the earphones of the operator's set loud receiver noise will be audible, provided the correspondent's carrier frequency is absent.
5. A call is sent to the correspondent with the ringing key shifted to position **CJ. BM3.** ("SERVICE CALL") and then reset in the center position. (When working with an R-401 station, the key is shifted to position **BM3** ("CALL")).

When sending a call, the indicator arrow on the transceiver section will fluctuate.

6. The correspondent is called, with the call letters of his station and the calling station identified. The button of the operator's set must be held down when calling. The presence of the correspondent's carrier frequency is detected by the suppression (weakening) of receiver noises or the audibility in the earphones of a tone when the call is being sent.

When the correspondent replies, the receiver AFC is switched on (switch **BMKJ** ("AFC-OFF") is placed in position **BMJ** ("AFC")) and the telephone and telegraph channels are adjusted (see below).

7. Upon receipt of a service call from the correspondent, the bell rings and the red signal lamp lights at the station. When an operational call is received from an R-401M (or a call from an R-401) only the red lamp glows on the telephone channel section. The call having been received, the correspondent is answered by setting the speech key of that telephone channel over which the call was received in position **P.KAH.** ("RADIO CHANNEL").

If there is no communication within 10-15 minutes of the scheduled time for the initiation of traffic, the antenna-transmission line units (see Section 15) and the antenna orientation should be checked. Once there is no doubt that the equipment is in good operating condition and that the antenna is properly oriented, communication is established with the correspondent.

If, after a second effort, there is still no communication with the opposite station, then, after discontinuing station operation, measures are taken to establish radio relay communication using other channels (wire or radio).

When establishing communication and conducting service calls, operators should confine themselves to the service call table. After communication has been established, the telephone and telegraph channels are adjusted.

Adjustment of the Telephone Channels

The adjustment of the telephone channels includes the following sequence of operations to be performed in both directions of the radio link:

- adjustment of the level of the test oscillator;
- adjustment of the transmitter frequency deviation;
- adjustment of the receiving level at the output of the telephone channel.

Adjustment of the Level of the Test Oscillator

The level of the test oscillator is adjusted at the telephone channel section in the following order:

- the switch of the indicator device is placed in position ИГ ("TEST OSCILLATOR");
- the ringing key is set in position СЛ-ВМЗ ("SERVICE CALL"); when working with an R-401 station, it is set in position ВМЗ ("CALL");
- by turning the potentiometer shaft of the ringing oscillator ИГ , the indicator device arrow is centered in the colored sector.

Adjustment of the Transmitter Frequency Deviation

The transmitter frequency deviation is adjusted only when the second telephone channel is adjusted. When regulating the first telephone channel and the telegraph channels the agreement of the readings of the indicator device on the transceiver section with the frequency deviation table is checked; the indicator readings may differ from the table data by $\pm 15\%$.

-
- * The frequency deviation table gives indicator readings for only three frequencies of the band. On other frequencies, indicator readings are assumed equal to the value indicated for the nearest frequency.

The transmitter frequency deviation is set in the following sequence:

1. The left-hand switch of the indicator device on the transceiver section is set in position BX. ПЕР. ("TRANSMITTER INPUT").
2. The required reading of the indicator device for the particular fixed frequency set on the transmitter is determined according to the table of transmitter frequency deviations which will be found with each equipment half-set*.
3. The following adjustments are made on the telephone channel section:
 - the telephone channel monitoring key is set in position I (when conducting service calls over channel I);
 - the speech key of the second telephone channel is set in position P.KAH ("RADIO CHANNEL");
 - the ringing key is set in position C.M. БУЗ ("SERVICE CALL").
4. On the transceiver section, potentiometer "УСТ. УРОВНЯ" ("LEVEL SETTING") is used to set the indicator arrow on the division determined according to the transmitter frequency deviation table for the second telephone channel.
5. A check is made of the transmitter frequency deviation over the first telephone channel, requiring that:
 - the speech key of the second telephone channel be placed in the center position;
 - the telephone channel monitoring key be placed in position II (for conducting service calls over channel II);
 - the speech key of the first telephone channel be placed in position P.KAH ("RADIO CHANNEL") and a check be made of the agreement of the indicator readings with the frequency deviation table.
6. After the frequency deviation of the transmitter has been checked over both channels, the speech keys and ringing key are placed in the center position.

Adjustment of the Receiving Level at the
Output of the Telephone Channel

The receiving level at the output of the telephone channel is set in the following sequence:

- The correspondent is requested to send a transmission level.

* See logbook for more accurate deviation readings.

- The speech key of the first (second)* telephone channel is set in position P.KAH ("RADIO CHANNEL").
- Indicator device switch is set in position Y1 (Y2).
- By turning the shaft of potentiometer 1 (A), the indicator arrow is centered in the colored sector.
- The station transmitting the test level is advised over the first (second) telephone channel that the adjustment of the telephone channel has been completed.

There may be frequent instances during the operation of the stations, especially when branching off channels from high-capacity multichannel radio relay stations, when operation over the link will be exclusively through telephone channels. In such cases, in order to improve the quality of the telephone channels, it is advisable to increase the frequency deviation of the transmitter (the indicator reading should be 1-2 times greater than that indicated in the table).

If there are significant changes in environmental temperature (of 20-30°C), readjustment of the receiving levels is essential.

Connection and Adjustment of Telegraph Channels

The power supply for the telegraph channels is connected by means of switches AKK-BMKJ-CETb ("BATTERIES-OFF-MAINS") of the telegraph channel section. Each telegraph channel has its own switch. When the station is running on storage batteries, the switches must be set in position AKK ("BATTERIES"), and in the case of mains operation - in position CETb ("MAINS").

Telegraph channels are adjusted only between terminal stations of a link by means of the telegraph channel adjusting device and the relay which is a part of the equipment of the station. Telegraph channels are adjusted in bipolar operation (Baudot) simultaneously in both directions, regardless of the mode in which the telegraph channels are to operate.

Connecting and Preparing to Work with the Telegraph Channel Adjusting Device

The device is connected and prepared for operation in the following sequence:

- the power cable of the device is connected to the $\pm 60v$ block on the line board;
- the operation selecting switch of the device is set in position ПРОб. АТ. ("TEST");
- the power for the first (second) telegraph channel is switched on;

* Given in the parentheses is the position of keys, switches, etc., when setting the receiving level over the second telephone channel.

- the power switch is placed in position BKЛ ("ON");
- by turning the potentiometer handle of the device marked ПРСОСЛ ("BIAS"), the indicator arrow is made to fluctuate around zero;
- the button for connecting the shunt of the indicator device marked ЧРСТБ ("SENSITIVITY") is depressed and, by means of the same potentiometer, the indicator arrow is made to fluctuate around zero.

Adjusting the Telegraph Channels

Each telegraph channel is adjusted in the following sequence:

1. The telegraph channel switches on the telegraph channel section are placed in the following positions:

- switch OKOH-ПРСОБ-РЕТР ("TERMINAL-CHECK-RELAY") - in position OKOH ("TERMINAL");
- channel operating mode switch - in position 5040 ("BAUDOT").

2. The jack on the telegraph channel adjusting device is connected, by means of a special wire which is part of the equipment, to the line board. The line board switches must be in the "OFF" position (ВЫКЛ).

The connection of the special wire to the line board terminals is made as follows:

- the conductor marked "ПР" ("TRANSMISSION") to terminal 11 (13)*;
- the conductor marked "ПР" ("RECEPTION") to terminal 12 (14);
- the conductor marked "3" ("GROUNDING") to terminal 19, 20 or 21.

During adjustment of the channels, the connecting lines must be disconnected from the line board.**

3. The operation selecting switch of the telegraph channel adjusting device is set in position 5040 ("BAUDOT"). Fluctuations of the arrow of the indicator device on the telegraph channel adjuster should be observed at the opposite station.

4. The indicator device switch on the telegraph channel section is placed in position BT ("INCOMING CURRENT").

* Here and throughout, the terminals and other units for the second telegraph or telephone channel are indicated in parentheses.

** If the telegraph channel adjusting device is connected to the jack on the telegraph channel section by means of a double-plug cord, disconnection of the connecting lines is not mandatory, although in this case check-out of certain circuit elements is impossible.

5. The button marked BX. TOK ("INCOMING CURRENT") on the telegraph channel adjusting device is depressed and by means of the rheostat marked BX. TOK on the telegraph channel section the indicator arrow is set at division 0.25. The button is then released.

6. The agreement of the indicator readings with the table of deviations is checked with the left-hand switch of the transceiver section indicator device set in position ПЕР ("TRANSMITTER").

7. Using the potentiometer marked ПРИБЛ. ("BIAS") of the telegraph channel section, the indicator arrow on the telegraph channel adjusting device is made to fluctuate around zero. Then the button marked ЧВСТБ. ("SENSITIVITY") is depressed and again the arrow is zero-centered.

8. In the event of considerable temperature changes (of 20-30°C), the neutrality of the telegraph channels must be checked.

6.

Operation of the Station in the Terminal Mode

Wire Connecting Lines

As wire connecting lines from the elements of the communication center to the radio relay stations the following cable types may be used: P-271, TTVK-5x2, PTF-7, PTG-19 and P-274. The permissible attenuation for telephone channel wire connecting lines is 1 neper. When using P-271 cable, the length of the connecting lines may be as much as 25 km; as much as 4 km with PTF-7 or P-274 cable, and as much as 6.5 km with PTG-19 cable.

Separate connecting lines may be run to the telegraph channels, or else the lines of the first and second telephone channels may be employed.

The connecting line to the first telephone channel may be used for operation over the first telegraph channel, and the connecting line to the second telephone channel for operation over the second telegraph channel. In this case, the connecting lines to the telephone channels must be connected through line transformers.

At the radio relay station, when connecting the line transformers to the lines, switches 1 ТГ (II ТГ) - ВУКЛ - 4П. I ТГ (4П. II ТГ) (1st TG or 2nd TG - OFF - 4-WIRE 1st TG or 4-WIRE 2nd TG), located on the line board (Fig. 84), are placed in position I ТГ (II ТГ).

When separate connecting lines are run to the telegraph channels, these switches must be placed in position ВУКЛ ("OFF") or 4П. I ТГ (4П. II ТГ) ("4-WIRE 1st TG" or "4-WIRE 2nd TG"), depending on the type of circuit used to connect the telegraph sets. When working with P-100 telegraph equipment or in the case of duplex operation of ST-35 equipment, the midpoints of the telephone channel connecting lines can be used for transmission only, and separate connecting lines must be run for reception.

If ground return is used in telegraph operation, then reliable working requires that particular care be taken when grounding the station*.

In order to effect a good grounding, a hole 30-50 cm in depth must be dug (to below the front line in winter) and the grounding rods, which are connected to the terminal marked "ground" at the van input recess, should be driven into the earth from the bottom of this hole.

Groundings should be made in damp places. If it is impossible to effect a good grounding (sandy or rocky soil, solidly frozen ground, etc.), an additional single-wire connecting line, used as a second (return) wire, must be run between the radio relay station and the distributing frame of the telegraph station.

All wire lines running to the radio relay station must be tagged to indicate the number of the jacks to which they are connected on the switchboard or distributing frame.

If there is a communication failure between the communication center and the station over the wire lines, the lines should be rung through and the insulation resistance between conductors and with respect to ground should be checked.

The lines may be checked with special test instruments (type IPL-48 or the device which is part of the standard equipment of switchboard P-194). If these instruments are not available, a TT-2 tester or Ts-20 volt-ammeter may also be used. The lines may be tested directly at the line board of the station, after unscrewing the pertinent fuses on the board.

Telephone Channel Operation

In order to prepare the telephone channels of the station for operation, the following procedure must be carried out:

1. Adjust the telephone channels of the radio link.
2. Connect the wire connecting lines to the first and second telephone channels to terminals 1-2 and 5-6 of the input recess, respectively.
3. Check the transmission of speech and ringing in the direction of the switchboard and in the opposite direction.

To call the switchboard:

- the speech key of the proper telephone channel is set in position KOM ("SWITCHBOARD");

- the ringing key is set in position B43 or C41. B43 ("CALL" or "SERVICE CALL") and then reset in the center position.

* In those cases when multiconductor cable more than 5 km in length is used for the connecting lines, the telegraph machines must be connected over a four-wire balanced circuit.

4. When the operator on duty at the switchboard answers, request him to check the transmission over the radio link of both the signalling and actual call. Speech keys must now be in the center position. The transmission of the calling signal over the radio link is indicated by the glow of the signal lamps marked KOM ("SWITCHBOARD") or P. KAH ("RADIO CHANNEL") and the bell. In the case of an incoming call over a wire line from a switchboard to a radio station, the green light flashes and the bell rings, whereas if the call is received by radio, only the red lamp lights.

After a communication check has been made (of both calling and talking) over both telephone channels between the switchboards of the communication centers, the channels are ready for operation.

Telegraph Channel Operation

Operation of Telegraph Channels in the Single-Wire Simplex Mode (Simplex Operation with ST-35 Equipment)

The following is the procedure for preparing telegraph channel for operation in the single-wire simplex mode:

1. Adjust the telegraph channel.
2. Connect the connecting line from the telegraph station to terminal 11-13 of the input recess, and the ground wire to terminal 19-20 or 21.
3. Set the line circuit switch on the line board to position BKJL ("OFF").
4. Set the switches on the telegraph channel section to the following positions:
 - operating mode switch - to position OKOH ("TERMINAL");
 - operation selecting switch - to position 2NP. ("TWO-WIRE");
 - indicator device switch - to position BT ("INCOMING CURRENT") for the proper channel.
5. Adjust, by means of the rheostat marked BX. TOK ("INCOMING CURRENT") to the 0.5 division when working with ST-35 equipment. This corresponds to a line current of 50 ma.
6. Set the indicator device switch to position TM and, by means of the rheostat marked OOM., ("FIELD CURRENT") center the indicator arrow in the middle of the colored sector.

When operating the set over connecting lines consisting of cable type P-271 or P-271M more than 4 km in length or over a permanent overhead line more than 50 km in length, the transmission branch of the telegraph channel should be adjusted using letter "T" (see below).

7. When the telegraph set at the other terminal station of the radio link is connected to the telegraph channel, place the operation selecting switch in position 1NP ("SINGLE-WIRE").

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With the operation selecting switch in this position, the line circuit of the telegraph set passes through the right-hand contact and armature of the receiving relay. The armature of the receiving relay will be located at the right-hand contact only if a telegraph set is connected at the opposite terminal station of the radio link; otherwise, the armature will be located at the left-hand contact and the line circuit of the telegraph machine will be open.

8. Request the telegraph station to check the transmission of telegraph signals over the link. If the telegraph operation is being received unsatisfactorily at the other terminal, the transmission branch of the telegraph channel must be adjusted at the first station (sending station) using the letter "T" (see below). After the transmission branch of the telegraph channel has been adjusted over letter "T", the opposite telegraph station is again requested to check the telegraph operation over the radio link and the channel is ready for operation.

Telegraph Channel Operation in the Two-Wire Simplex Mode
(Duplex Operation with ST-35 Equipment)

The following is the procedure for preparing a telegraph channel for operation in the two-wire simplex mode:

1. Adjust the telegraph channel.
2. When operating over a two-wire (unbalanced) circuit, the connecting lines at the input recess (van ports) are to be connected:
 - for transmission - to terminal 11 (13);
 - for reception - to terminal 12 (14);
 - the ground wire - to terminal 19-20 or 21.

The line circuit switch on the line board is placed in position B K . ("OFF").

When operating over a four-wire (balanced) circuit, the connecting lines are connected:

- for transmission - one wire to terminal 11 (13), the other to terminal 21 (20) of the input recess;
- for reception - one wire to terminal 12 (14), the other to terminal 19 of the input recess.

The line circuit switch on the line board is placed in position 4NP, ITR (4NP, IITr) ("4-WIRE, 1st TG" or "2nd TG").

3. The switches on the telegraph channel section are placed in the following positions:

- operating mode switch - in position OKOH ("TERMINAL");
- operation selecting switch - in position 2NP ("2-WIRE");
- indicator device switch - in position BT ("INCOMING CURRENT") of the proper channel.

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4. By means of the rheostat marked BX. TOK ("INCOMING CURRENT"), set the indicator arrow to the 0.5 division when working with ST-35 equipment. This corresponds to a current of 50 ma.

5. Set the indicator device switch to position TΠ and, by means of the rheostat marked ΠOAM. ("FIELD CURRENT") center the indicator arrow in the middle of the colored sector.

When operating the set over connecting lines consisting of cable type P-271 of P-271M more than 5 km in length or over a permanent overhead line more than 50 km in length, the transmission branch of the telegraph channel should be adjusted using letter "T" (see following section).

6. When the telegraph sets at the other terminal station of the radio link are connected to the telegraph channel, check the current amplitude in the circuit of the receiving telegraph set (if the transmitting telegraph set has not been connected at the opposite station, the line circuit of the receiving set will be open). For this purpose, the indicator device switch is set in position WT ("OUTGOING CURRENT") and if the arrow is located outside the colored sector, the telegraph station is requested to set the current in the line circuit of the receiving set at 50 ma.

7. Request the telegraph station to check the transmission of telegraph signals over the link. If the telegraph operation is being received unsatisfactorily at the other terminal, the transmission branch of the telegraph channel must be adjusted at the first station (sending station) using the letter "T". After the channel has been adjusted over letter "T", the opposite telegraph station is again requested to check transmission over the link and the channel is ready for operation.

Adjusting the Telegraph Channel by Letter "T"

The following is the procedure for adjusting the transmission branch of a telegraph channel by means of letter "T":

1. Request one's own telegraph station to check and determine whether the machine is properly adjusted.

2. Connect and prepare for operation the telegraph channel adjusting device.

3. Place the switch marked OKOH-ΠPOB-PETP. ("TERMINAL-CHECK'RELAY") on the telegraph channel section in position ΠPOB. ("CHECK").

4. Disconnect the connecting lines from terminal 11 (13) of the van input recess (when working in single-wire simplex) or from terminals 11 (13) and 12 (14) (when operating in two-wire simplex) and connect the telegraph channel adjusting device to the line board terminals.

5. Set the telegraph channel operation selecting switch and the switch on the telegraph channel adjusting device to position 50AO ("BAUDOT").

6. Press the button marked *YBCTB ("SENSITIVITY") on the telegraph channel adjusting device and note the division near which the indicator arrow fluctuates.

7. Disconnect the wire of the telegraph channel adjusting device from terminal 11 (13) and connect to terminal 11 (13) of the van input recess the connecting line from the telegraph station.

8. Shift the telegraph channel selection switch to position 2 P ("2-WIRE") and the switch on the telegraph channel adjusting device to position COMM. 2AP ("2-WIRE SIMPLEX").

9. Request the telegraph station to send automatically the letter "T" from the machine.

10. Press the button marked MYBCTB ("SENSITIVITY") on the telegraph channel adjusting device and, by turning the shaft of the rheostat marked NOAM ("FIELD CURRENT") on the telegraph channel section, cause the indicator arrow to fluctuate around the same division which was noted in the transmission of d-c pulses from the telegraph channel adjusting device (see point 6 above).

11. Request the telegraph station to discontinue operation.

12. Disconnect the telegraph channel adjusting device*.

13. Place the switches on the telegraph channel section in the positions proper to the selected mode of operation.

Telegraph Channel Operation in the Bipolar Mode (Baudot)

The following is the procedure for preparing the telegraph channel for operation in the bipolar mode (Baudot):

1. Adjust the telegraph channel.

2. When working over a two-wire (unbalanced) circuit the connecting lines at the input recess are connected:

- for transmission - to terminal 11 (13);
- for reception - to terminal 12 (14);
- ground wire - to terminal 19, 20 or 21.

Place the line circuit switch on the line board in position BUKI. ("OFF").

When working over a four-wire (balanced) circuit, the connecting lines are attached as follows:

- for transmission - one wire to terminal 11 (13), the other to terminal 21 (20) of the input recess;
- for reception - one wire to terminal 12 (14), the other to terminal 19 of the input recess.

* When operating the telegraph channel in two-wire simplex, connect the connecting line for reception to terminal 12 (14) of the input recess.

On the line board the line circuit switch is set in position 4NP, ITr (4NP, IITr) ("4-WIRE, 1st TG" or "2nd TG").

3. The switches on the telegraph channel sections are placed in the following positions:

- the operating mode switch - in position OKOH ("TERMINAL");
- the operation selecting switch - in position 60A0 ("BAUDOT");
- the indicator device switch - in position BT ("INCOMING CURRENT") of the proper channel.

4. The telegraph station is requested to send a positive polarity and, by means of the rheostat marked BX. TOK ("INCOMING CURRENT"), the indicator arrow is set at the 0.25 division, corresponding to a line current of 25 ma.

5. The telegraph station is required to send a negative polarity and if the indicator reading differs from 0.25 by more than ± 0.05 divisions, the station is requested to equalize the voltages of the line batteries.

6. The indicator device switch is shifted to position MT ("OUTGOING CURRENT"). The indicator arrow should stand at the 0.25 division. If it does not, the station is requested to set the current in the line circuit at 25 ma.

7. When the telegraph set is connected at the opposite terminal station of the radio link, the telegraph station is requested to check the telegraph operation and the channel is ready for operation.

Monitoring and Service Communication

The transmission of an operational call over the radio link channel is announced by the signal lamps of the proper channel. When a call is received from the radio link a red light flashes. When a call is received from a switchboard a green light flashes and the bell rings.

Conversations over the radio link channels may be monitored by means of the operator's set with the telephone channel monitoring key placed in position I or II.

Telephone channel operation can also be monitored by the indicator device of the telephone channel section. For this purpose the switch of this indicator device must be set in position Y1 or Y2.

If there is no traffic over the telephone channel the indicator arrow will be located near the zero mark, while during conversations it will show a sharp deviation of 30-50 divisions, thus indicating reception. If a high-frequency signal is received from the opposite station the indicator arrow will move by 30-50 divisions and will fluctuate slightly, thus indicating the presence of noise in the channel.

The indicator device must not be used alone to monitor communication, but should always be used together with an actual audio monitoring of the calls.

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With the telephone channels connected over a four-wire system a call is monitored in the following manner:

- from the radio link - by means of the operator's set with the telephone channel monitoring key placed in position I or II;
- from the equipment to which the channels are connected - by the indicator device of the transceiver section with the left-hand switch of the indicator placed in position BX. MEP. ("TRANSMITTER INPUT"). During the conversations the indicator arrow will deviate sharply.

Telegraph channel operation may be monitored by means of the indicator device of the telegraph channel section in the following manner:

- with the indicator switch set in position BT ("INCOMING CURRENT") the line circuit of the transmitting set is monitored;
- with the switch set in position WT ("OUTGOING CURRENT") the line circuit of the receiving set is monitored;
- with the switch set in position 1T (2T), a check is made of the proper operating condition of the windings of the receiving relay of the telegraph channel.

When the telegraph machines are connected to the station but are not working, the indicator arrow in the first two cases should be located in the center of the colored sector (when working with ST-35 equipment) or on the 0.25 division (when working with P-100 equipment). When the indicator switch is placed in position 1T (2T) the indicator arrow should steady itself in the middle of the colored sector.

In the first two cases with P-100 telegraph equipment, the indicator arrow will hover about zero, while when working with ST-35 machines it will fluctuate between zero and the colored sectors.

When the indicator switch is set in position 1T (2T) the indicator arrow will fluctuate about zero when working with P-100 and ST-35 equipment.

For service communication between a terminal station of a radio link and elements of the communication center a separate wire communication line must be run. The service communication line is connected at the radio relay station to terminals 9-10 of the van input recess, while the telegraph set is connected to connected to terminals 9-10 of the corresponding line board.

In individual cases service calls with communication center elements may be made over the telephone channel connecting lines.

In the case of a temporary connection of a radio relay station, the power on the charging board must be connected in order to provide service communication over the telephone channel connecting lines.

Service communication between radio relay stations may be passed over any telephone channel free of operational calls. Before making a service call, the telephone channel monitoring key is set in position I or II and care is taken to ascertain that the radio link channel is free of operational calls.

For service calls with an R-401M station, the speech key of the free channel is set in position P. KAH ("RADIO CHANNEL") and the service call is sent.

In order to call a switchboard or an R-401 station, a normal operational call is sent. After the call has been sent, the required station is called by naming its call letters.

When a service call is received by radio, a bell rings at the station and the red signal lamp of the pertinent channel flashes.

To answer a call, the telephone channel monitoring key is set in position I (II). When one's own call letter has been heard, the speech key of the channel over which the call has been received is placed in position P. KAH ("RADIO CHANNEL"), and a reply is made. At the end of the service call, the speech key of the telephone channel is reset in the center position.

If a call is received from a switchboard or station of the radio link during a service conversation, the channel must be immediately made available for operational use.

When working with external multiplexing equipment service communication can be carried only over the first telephone channel. When working with secondary multiplexing equipment service communication may be carried only over the second telephone channel.

7.

Connecting the Channels of the R-401M Radio Relay Station to Wire Communication Channels and To Those of Other Radio Relay Stations

There will be frequent cases, when using the R-401M radio relay station, when its joint operation with wire communication facilities and other radio relay stations will be necessary.

Connection of Telephone Channels

The selection of the type of circuit used to connect the telephone channels of the station is made on the basis of the capabilities of the other communication facilities. When selecting a circuit arrangement for such a connection, it is important to bear in mind that telephone channel operation of maximum stability is achieved when the connection is made over a four-wire circuit.

A four-wire circuit with no relay of magneto ringing (mode 4T^m) is used to connect only the first telephone channel when multiplexed by P-313 equipment.

Connecting a Telephone Channel
Over a Two-Wire Circuit (2T⁰)

The following is the procedure to be taken when connecting the telephone channel of an R-401M station with the telephone channel of other communication facilities over a two-wire circuit:

1. Adjust the telephone channel of the R-401M station.

2. Place the switch TPAH3.-OKOH ("RELAY-TERMINAL") on the telephone channel section in position TPAH3 ("RELAY"). The operating selecting switch of the channel must be in position 2TØ ("TWO-WIRE TELEPHONE").

3. The wire connecting lines from the equipment, from which the connection is being made, are run to terminals 1-2 (5-6) of the input recess.

Connecting a Telephone Channel Over a Four-Wire
Circuit with Relay of Magneto Ringing (4TØ1)

The following is the procedure for connecting the telephone channel of an R-401M station with the telephone channel of other communication facilities over a four-wire circuit with relay of magneto ringing:

1. Adjust the telephone channel of the R-401M station.
2. Set the operation selecting switch of the channel, located on the telephone channel section, in position 4TØ1 ("FOUR-WIRE TELEPHONE WITH RELAYED RINGING").
3. At the input recess of the van of the R-401M connect the wire connecting lines as follows:
 - to terminals 3-4 (7-8) - from the output of the telephone channel of the equipment, the channels of which are being connected;
 - to terminals 1-2 (5-6) - from the input of the telephone channel of the equipment, the channels of which are being connected.

Connecting the First Telephone Channel Over a Four-Wire
Circuit without Relay of Magneto Ringing (4T)

Telephone channels multiplexed by tone telegraphy equipment are connected over a four-wire circuit with no relay of ringing.

The following is the procedure for connecting the first telephone channel:

1. Adjust the telephone channel of the R-401M station.
2. Set the operation selecting switch on the telephone channel section at position 4T ("FOUR-WIRE TELEGRAPH").
3. At the input recess of the van of the R-401M connect the wire connecting lines as follows:
 - to terminals 3-4 - from the output of the telephone channel of the equipment, the channel of which is being connected;
 - to terminals 1-2 - from the input of the telephone channel of the equipment, the channel of which is being connected.

Connection of Telegraph Channels

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The telegraph channels of the R-401M radio relay station are connected with those of other radio relay stations and with the channels of tone telegraphy equipment (a d-c connection) in the bipolar (Baudot) mode.

The following is the procedure for connecting the telegraph channel of the R-401M with that of other communication facilities:

1. Connect and adjust the telegraph channel between the R-401M radio relay stations.

2. At the van input recess of the R-401M station, connect the wire connecting lines as follows:

- to terminal 11 (13) - from the output of the telegraph channel of the equipment, the channel of which is being connected;

- to terminal 12 (14) - from the input of the telegraph channel of the equipment, the channel of which is being connected;

- to terminal 21 (20) - the ground wires from the outputs of the telegraph equipment, from which the connection is being made;

- to terminal 19 - the ground wires from the input of the telegraph equipment, from which the connection is being made.

3. The line circuit switch on the line board is placed in position "OFF" ("BWK").

8.

Multiplexing the Radio Channel of the Station by Wire Communication Equipment - Secondary Multiplexing of the First Telephone Channel

Multiplexing the Radio Channel of the Station by Wire Communication Equipment

The R-401M radio relay station permits external multiplexing of the radio channel by P-310, P-311 and P-312 multiplexing equipment.

When P-310 equipment is used for external multiplexing, telephone communication over the first channel is retained and three additional telephone channels are formed. However, the effective range of the station is reduced in this case to 10-12 km.

With external multiplexing by means of P-311 or P-312 equipment, with two racks at each terminal of the link, telephone communication is retained over the first channel and two additional telephone channels are formed. Station range in this event is reduced to 20-25 km.

With external multiplexing by means of P-311 and P-312 equipment, with two racks of each type in use at the terminal stations, telephone communication is

retained over the first channel and four additional telephone channels are formed. The effective range of the station is reduced to 10-12 km.

Operation with external multiplexing equipment requires the following steps:

1. Establish communication over the radio link and adjust the first telephone channel.
2. Connect the connecting lines from the multiplexing equipment as follows:
 - to terminals 15-16 of the van input recess for transmission;
 - to terminals 17-18 of the van input recess for reception.
3. Set the station operating mode switch BHTP. ~~YH~~-BHEH. OKOH-BHEH. PETP ("INTERNAL MULTIPLEXING-EXTERNAL TERMINAL-EXTERNAL RELAY") on the telephone channel section to position BHEH. OKOH. ("EXTERNAL TERMINAL").
4. Set the left-hand switch of the transceiver section indicator device to position BX. ~~HE~~P. ("TRANSMITTER INPUT").
5. By means of the potentiometer marked ~~YH~~ (multiplex) on the telephone channel section, set the transmitter frequency deviation for the external multiplexing channel in accordance with the frequency deviation table. If the frequency deviation of the external multiplexing channel is not indicated in this table, then the transmitter frequency deviation is set in the following fashion:

Setting the Deviation from P-310 Multiplexing Equipment

1. Send the control frequencies and normal test level over the first channel of the P-310 multiplexing equipment.
2. By means of the potentiometer marked ~~YH~~ (multiplex) on the telephone channel section, set a transmitter frequency deviation which corresponds to the first telegraph channel of the R-401M radio relay station in accordance with the table.

Setting the Deviation from P-312 (P-311) Multiplexing Equipment

1. Send a call over one of the HF channels of the P-312 (P-311) multiplexing equipment.
2. By means of the potentiometer marked ~~YH~~ (multiplex) on the telephone channel section, set a transmitter frequency deviation which corresponds to the second telephone channel of the R-401M radio relay station in accordance with the table.

Setting the Deviation with Joint Operation of P-311 and P-312 Multiplexing Equipment

1. Send a call over one of the HF channels of the P-312 multiplexing equipment.

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2. By means of the potentiometer marked Y (multiplex) on the telephone channel section, set a transmitter frequency deviation which corresponds to the first telegraph channel of the R-401M radio relay station in accordance with the table.

Secondary Multiplexing of the First Telephone
Channel by Telegraph Channels

The first telephone channel of the R-401M radio relay station can be multiplexed by telegraph channels using P-313 multiplexing equipment or equipment similar to it. In the case of secondary multiplexing of the first telephone channel, the following steps must be carried out:

1. Establish communication and adjust the telephone channels.
2. Set the operation selecting switch of the first telephone channel in position 4TF ("FOUR-WIRE TELEGRAPH").
3. Connect the connecting lines from the multiplexing equipment as follows:
 - to terminals 3-4 of the van input recess for transmission;
 - to terminals 1-2 of the van input recess for reception.

Place the channel in operation.

The remaining channels of the station are set up for operation in the manner described in Sections 5, 6 and 7 of this Chapter.

9.

Operation of the Station in the Relay Mode

Preparation of an intermediate station of a radio link for operation consists in the following:

1. Connect both equipment half-sets, establish communication in both directions and adjust the telephone channels.
2. Upon instructions from the main station of the link, switch the channels to the relay mode.

In order to switch the telephone channel to relay operation, the operating mode switches on the telephone channel sections of both half-sets must be placed in position PETP ("RELAY").

In order to switch the telegraph channels to relay operation the operating mode switches on the telegraph channel sections of both half-sets must be placed in position PETP ("RELAY"). Since the telegraph channels are relayed over supersonic frequencies, the power supply of these channels is not connected.

3. After communication has been established between terminal stations, adjust the telephone and telegraph channels of the link.

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Adjustment of the Telephone Channels of the Radio Link

The telephone channels are adjusted as follows. At the terminal station a signal from the test oscillator is fed to the second telephone channel and the transmitter frequency deviation is set (see Section 5 of this Chapter). This signal is received at the intermediate stations - for example, by the receiver of half-set A - and is fed over a connecting cable to the transmitter of half-set B where it causes a change in the frequency of the master oscillator. It is important that the received signal provide normal transmitter frequency deviation. In order to check the frequency deviation of the transmitter of half-set B, the left-hand switch of the indicator device on the transceiver section of this half-set is placed in position BX.ΠEP ("TRANSMITTER INPUT"). If the received signal level provides for normal transmitter frequency deviation at half-set B, the indicator arrow will move to the proper division according to the standard table for setting the transmitter frequency deviation. If the level is high or low, then, using the potentiometer marked √CT.YPOBHΛ ("LEVEL SETTING") on the transceiver section of half-set B, the indicator arrow is set to that division according to the table which corresponds to the normal transmitter deviation. The terminal station from which the test level is being sent is advised over the other telephone channel that the receiver frequency deviation has been set. The same method is used for setting transmitter frequency deviation at the second intermediate station, and so on. After the normal frequency deviation of the transmitters at the intermediate stations has been set, the receiving level at the telephone channel output is adjusted at the second terminal station, as discussed in Section 5 of this Chapter.

When adjusting the first telephone channel at the intermediate stations, a check is made of the agreement of the readings of the transceiver section indicator device with the frequency deviation table. The indicator readings may differ from those of the table by as much as $\pm 15\%$. See the log book for more accurate values.

After the telephone channels have been adjusted in one direction, the same technique is used to adjust them in the opposite direction.

If while adjusting the first telephone channel the indicator readings differ by more than $\pm 15\%$ from the data given in the table of transmitter frequency deviations, then at the very first opportunity the station is sent to a repair workshop, and normal operation over the second telephone channel is provided by switching from one half-set to the other over a four-wire circuit (low-frequency rerouting). This requires that:

1. the telephone channel be switched to the terminal mode at both half-sets;
2. the terminals of the line boards be connected as follows;
 - 1-2 of half-set A with 3-4 of half-set B;
 - 1-2 of half-set B with 3-4 of half-set A;
3. the telephone channel operation selecting switch on the telephone channel sections of both half-sets be placed in position 4T ("FOUR-WIRE TELEGRAPH");

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4. that when transmitting a test oscillator signal from the terminal station a check be made of the agreement between the readings of the transceiver section indicator device and those of the frequency deviation table (if the indicator arrow deviates by a greater or smaller number of divisions) potentiometer 1 of the telephone channel section of the other equipment half-set is used to set it on the division indicated by the frequency deviation table;

5. the operation mode switches on the telephone channel sections be placed in position 4T01 after the channel has been adjusted in both directions.

The tactico-technical specifications of the R-401M radio relay station permit the installation of two intermediate points on a radio link. In many instances, however, the number of intermediate stations may be increased to four or five. In this case, in order to provide identical channel quality, it is advisable to switch from one channel to another over a four-wire circuit at the central intermediate station of the line. This requires that the telephone channels be placed in the terminal operation mode, while the transmission of the signals from one half-set to the other is effected by connecting the proper line board terminals.

Adjustment of the Telegraph Channels of the Radio Link

The telegraph channels of the radio link are adjusted at the terminal stations in the manner described in Sections 5 and 6 of this Chapter.

At the intermediate stations, only a check is made to determine whether the readings of the transceiver section indicator device are in agreement with the frequency deviation table. For this purpose the telegraph channel operating mode switch at the terminal station is placed in position "+" or "-".

If at any intermediate station the readings of the indicator device on the transceiver section differ markedly from the value given in the table, the given telegraph channel at both half-sets is placed in terminal mode, the power supply is connected and relay is effected with bipolar (Baudot) operation by connecting the proper terminals of the line boards (see Section 7).

Relay When Operating with External Multiplexing Equipment

When the terminal stations are operating with external multiplexing equipment, the transition to the relay mode at the intermediate station requires the following steps:

1. The station operating mode switches on the telephone channel sections of the half-sets are placed in position BHEWH.PETP ("EXTERNAL RELAY").
2. The first telephone channel is placed in the relay mode. This channel is adjusted in the manner outlined above.

Adjustment of the external multiplexing channel at the intermediate station consists in setting the frequency deviation of the transmitters with a test level sent from the external multiplexing equipment at the terminal stations. The frequency deviation of the transmitters at the intermediate station is set so as to be identical to that at the terminal stations for the corresponding type of multiplexing equipment (see Section 8).

The Branching Off of Channels at an Intermediate Station
(Operating the Station as a Junction Point)

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Telephone and telegraph channels may be branched off at an intermediate station. Such channels are operated in the terminal mode.

In order to switch the telephone channels to the terminal mode, the operation selecting switches at both half-sets are set in the position corresponding to the type of operation (2TØ, 4TØ1, etc.).

In order to switch the telegraph channels to the terminal mode, the operating mode switches on both half-sets are placed in position OKOH ("TERMINAL").

After the channels to be branched off have been switched to terminal mode, they are adjusted. The connecting lines are connected and the channel is placed in operation. Only the receiving level is set when adjusting telephone channels which are branched off.

Monitor and Service Communication

The transmission of a call over the telephone channels of the radio link is called to the attention of the intermediate stations by the signal lamps of the proper channel at that half-set from which the call went forth. The call is monitored at the intermediate station by means of the telephone channel monitoring key. The call may be monitored from each half-set only in one direction.

Service communication with radio-relay stations may be passed over any free telephone channel.

When a call is received indicating that a station of the link is being summoned, the telephone channel monitoring key is placed in the position of the proper channel at the half-set for the direction from which the call was received. The call is now monitored by ear. If the call letters of one's own station are heard, the speech key of this channel is switched to position P.KAH ("RADIO CHANNEL") and a reply is made. When the call has been completed the telephone channel keys are set in their central position.

From an intermediate station a call is sent to a switchboard (operating call) or any station of the link (service call) in the following manner. By means of the monitoring key on the equipment rack of the required direction, a channel over which there is no operational traffic, is selected. The channel speaking key is set in position P.KAH ("SPEECH CHANNEL"). The key marked C/Л.ВМЗ - ОЛ.ВМЗ. ("SERVICE CALL-OPERATIONAL CALL") is used to send the proper type of call and the call letters of the station or switchboard being summoned are named. When the call is finished the telephone channel keys are set in their central position.

If during service calls a call comes in from another direction, the red signal lamp will flash on the other half-set. In this case the channel must be made immediately available for the operational calls.

With secondary multiplexing of the first telephone channel service communication is possible only over the second telephone channel. With relay of external multiplexing service communication is possible only over the first telephone channel.

10.

Station Operation with the Power Amplification Section

Operation of the station with the power amplification station is permitted only in the following circumstances:

- in mobile operation;
- in the case of severe interference from the enemy;
- in the event that it is necessary to establish communication over intervals of great length.

In all other cases reliable and stable communication is provided without the use of the power amplification section.

The power amplification section makes it possible to increase the output of the station transmitter by approximately ten times. It should be borne in mind in this connection that increasing the transmitter output leads to the following negative results:

- there is an increase in the probability of interference to the other directions of the radio relay communication system;
- interception by the enemy of the traffic of the station is facilitated.

In addition to the above, it should also be considered that with the power amplification section in use, the consumption of electric energy from the power supply sources increases by approximately two times. It is particularly important to bear this fact in mind when operating with storage batteries.

Connection and Disconnection of Power Supply for the
Power Amplification Section

Connection of Storage Battery Power Supply

When operating only a single half-set, the power amplification section may be fed both from a discharging battery group of the operating half-set, as well as from any battery group of the second half-set.

In the first instance, connection of the power supply requires that the power switch of the power amplification section on the charging board of the operating half-set be placed in position YM. ("POWER AMPLIFICATION").

In the second instance, the switch of the selected battery group on the charging board of the inoperative half-set is placed in position PA3PA4 ("DISCHARGE") and the power switch of the power amplification section is placed in position YM ("POWER AMPLIFICATION").

With both half-sets of the station in operation, the power amplification section may be fed from a discharging battery group of either half-set. To connect the power in this instance, the power switch of the power amplification section on the charging board of the selected half-set is placed in position YM ("POWER AMPLIFICATION").

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Connection of the Power Amplification Section in the Case of
Battery Power Supply

When fed from the storage batteries, the power amplification section is connected in the following sequence:

1. Connect the power from the storage batteries.
2. Set the switch of the indicator device of the power amplification section to the 500v position.
3. Set the power mode switch of the power amplification section to position AKK ("STORAGE BATTERIES"). The arrow of the indicator device of the power amplification section should be deflected by 100 ± 20 divisions.

Connection of the Power Amplification Section in the Case of
Mains Power Supply

When fed from the a-c mains, the power amplification section is connected in the following sequence:

1. Set the power selection switch of the section in position B K ("OFF").
2. On the charging board;
 - set the on-off power switch of the section in position BKK1 ("OFF");
 - set the selection switch PA3P11-BKK1-3AP11 ("DISCHARGE-OFF-CHARGE") in position BKK1 ("OFF") if the power amplification unit was being fed from storage batteries of the reserve (standby) half-set. (If, on the other hand, the section has been powered from a storage battery group of the operating half-set, the latter operation is not performed.)

In order to disconnect the power amplification section when the station is being operated on a-c mains current, the power selection switch of the section must be set at position BKK1 ("OFF").

Connecting the Station for Operation with the Power
Amplification Section

The station is connected for operation with the power amplification section in the following sequence:

- the transmission line (feeder) of the transmitting antenna is connected to the output of the power amplification section;
- the high-frequency input cable of the power amplification section is connected to the output of the transmitter;
- the station is set for standby operation and the working frequencies are adjusted at the receiver and transmitter*;

* See footnote on following page.

- the station transmitter is turned on;
- the power supply for the power amplification section is turned on;
- the power amplifier is tuned to the transmitter frequency and communication is established.

To tune the power amplifier to the transmitter frequency it is necessary:

- to set the switch of the indicator device of the section to position AHT (monitoring of the power at the output of the power amplifier);
- to free the arresting device of the control marked НАСТРОЙКА ("TUNING"), by turning it in a counter-clockwise direction;
- to achieve the maximum reading of the indicator device by tuning the above mentioned control;
- to lock the tuning control by means of its arresting device, turning the latter in a clockwise direction.

Switching the Station to Operation with the Power
Amplification Section

If the transmitter of the station has been working and it becomes necessary to switch it to operation with the power amplification section, the following steps must be taken:

- switch off the transmitter (go over to the standby reception mode);
- disconnect the transmission line (feeder) of the transmitting antenna from the transmitter and connect it to the output of the power amplification section;
- connect the high-frequency input cable of the power amplification section to the transmitter output;
- switch on the transmitter;
- switch on the power supply for the power amplification section;
- tune the power amplifier to the transmitter frequency.

* FOOTNOTE TO PRECEDING PAGE: When operating with the power amplification section the minimum permissible frequency separation in the receiver and transmitter may be 35 fixed frequencies in the 60-69.975 Mc band and 27 fixed frequencies in the 66-69.975 Mc band.

When operating the station without the power amplification section the minimum permissible frequency separation in receiver and transmitter may be 15 fixed frequencies in either segment of the band.

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Switching the Station to Operation without the Power
Amplification Section

The transmitter is switched over to operation without the power amplification section in the following order:

- switch off the power supply of the power amplification section;
- switch off the transmitter (go over to the standby reception mode);
- disconnect the high-frequency input cable of the power amplifier from the transmitter output;
- disconnect the transmission line (feeder) of the transmitting antenna from the output of the power amplifier and connect it to the transmitter output;
- switch on the transmitter.

11.

Operating the Station with the Frequency Filter Section

The frequency filter section is designed to permit simultaneous operation of the receiver and transmitter of a station over a single antenna.

Operation of the receiver and transmitter over a single antenna is provided in order to permit communication while in motion. In this case, the mobile station operates with a whip antenna, while the fixed station must operate over an antenna having vertical polarization.

Operation over a single antenna having vertical or horizontal polarization is also possible between two fixed stations. In the latter instance, it is more advisable to employ an antenna with horizontal polarization, since when working with an antenna of this kind the attenuation of the high-frequency signal over the link will be somewhat smaller than when operating over an antenna having vertical polarization. In selecting the working frequencies for communication it must be remembered that the antenna with horizontal polarization is tuned to a frequency of 62.5 Mc and operates in the lower portion of the band of the station (from the 21st to the 87th fixed frequency). In this band it provides greater gain in the HF signal, displays a narrower radiation pattern and is better matched with the transmitter output (receiver input). The vertical polarization antenna, on the other hand, shows better characteristics in the upper portion of the band (from the 88th to the 154th fixed frequency).

When operating the station with the frequency filter section over a single antenna the working frequency separation for transmission and reception must be equal to 67 fixed frequencies; that is, greater than the frequency band covered by each of the antennas. Consequently, one of the communication frequencies will always be outside the limits of the working segment of the antenna band.

In order to provide for approximately identical communication conditions in opposite directions, the working frequencies must be so chosen that the frequency, which is outside the limits of the antenna band segment, be as close as

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possible to the working band of the antenna. When operating the station over antennas of different polarity, the permissible frequency separation of the receiver and transmitter may differ from the fixed.

Connecting the Receiver, Transmitter and Antenna of the
Station to the Frequency Filter Section and Tuning the Section

The following is the procedure for connecting the transmitter, receiver and antenna of the station to the frequency filter section:

1. Connect to the high-frequency plug of the frequency filter section the transmission line of the antenna of chosen polarity or the transmission line of the whip antenna.

2. On the frequency filter section set the switches marked ПА3НОС БОЖИ ("FREQUENCY SEPARATION") in position 67 when working with an R-401M station or in position 27 when working with an R-403 station.

3. Connect the high-frequency cables of the frequency filter section to the high-frequency plugs of the transmitter (power amplifier) and receiver.

The high-frequency cable of the left-hand branch of the filter frequency section is connected to that element of the station (receiver or transmitter), the working frequency of which falls within the 60-65 Mc band (21-87 fixed frequencies) or within the 66-68 Mc band (107-127 fixed frequencies) when operating the R-401M with an R-403 station.

The high-frequency cable of the right-hand branch of the filter frequency section is connected to that element of the station (receiver or transmitter), the working frequency of which falls within the 65-70 Mc band (88-154 fixed frequencies) or within the 68-70 Mc band (128-154 fixed frequencies) for operation with an R-403 station.

4. Set the dial illumination switch for the frequency filters in the "ON" position (BKM). The dial illumination lamps are now switched on.

5. By turning the tuning controls, align the graduation lines with the numbers of the fixed frequencies on the dials so that the vertical lines on the cross wire and the graduation lines on the dial, corresponding to the working frequencies of the transmitter or receiver, coincide*.

* The dials are calibrated for a separation of 67 fixed frequencies and a separation of 27 fixed frequencies in different colors which correspond to the color of the numbers 67 and 27 on the forward panel.

12.

Operating the Station in Motion

In order to operate the station while in motion the receiver and transmitter must be connected to the whip antenna through the frequency filter section. The fixed station of the correspondent, in this case, must operate over a vertically polarized antenna which must also be connected to the receiver and transmitter through a frequency filter section. When operating an R-401M station in motion with an R-401 station in a fixed position, the Yagi antenna system on the latter must be turned to an angle of 45°, as shown in Fig. 14.

When communicating with a station in motion, the orientation of the antenna at the fixed station must be checked and, depending on the movement of the mobile station, the antenna must be periodically oriented for best audibility (maximum noise suppression). If audibility should become severely impaired, the coordinates of the mobile station are to be requested and the antenna oriented accordingly. If this does not result in improved audibility, the mobile station should be requested to switch to a different operating mode.

The mobile station may operate in different modes. The range of communication with a fixed station, depending on the operating mode of the mobile station, is not less than:

- 10 km when working in duplex without the power amplification section;
- 15 km when working in duplex with the power amplification section;
- 20 km when operating over a single channel (transmitter off during reception) without the power amplification section;
- 25 km when operating over a single channel with the power amplification section.

The operating mode is chosen on the basis of the distance to the fixed station and the quality of communication propagation.

In the case of worsening communication, the mobile station, before switching to another mode of operation, must advise the fixed station of its coordinates. If, after the antenna of the fixed station has been properly oriented, audibility at the mobile station does not improve, the fixed station is requested to switch to another mode of operation.

The fixed station may operate in two modes:

- duplex without the power amplification section,
- duplex with the power amplification section.

In order to make possible a rapid transition from operation without the power amplification section to operation with this section, the power amplifier at both stations is to be tuned to the transmitter frequency.

For switch-over to the single-channel mode of operation the switch marked O HOK.-OKOH ("SINGLE CHANNEL-TERMINAL") on the telephone channel section must be set in position OAHOK. ("SINGLE CHANNEL"). In this case the transmitter is switched off (the voltage is removed from its tubes). The transmitter is switched on by depressing the button of the operator's handset during the transmission of commands or reports. The transmitter must be off (button released) during reception.

13.

Removal and Operation of the Equipment Outside the Van

The operational situation may on occasion require that the station be set up in shelters (bunkers), buildings in elevated locations and other places where access by truck is difficult or impossible. The radio relay station is so designed as to permit rapid disassembly of the equipment and its removal for installation at any other site.

When an equipment half-set is set up for operation outside the truck van the following essential components are necessary:

1. The filter frequency section (in the event operation is proposed over an antenna of one polarization) 1 Unit
2. The telephone channel section with the operator's set 1 Unit
3. The telephone channel section and device for adjusting the telegraph channels (when telegraph communication is established over the radio link) 1 Unit
4. The transceiver section 1 Unit
5. The line board 1 Unit
6. The rack frame 1 Unit
7. 5NKN-45 storage batteries 2 Units
8. Case with antenna gear and transmission lines 1 Unit
9. Antenna mast with rigging 2 Sets
10. Mast erector 1 Unit
11. Battery connecting cable 1 Unit

When transporting the equipment to the deployment site it should be protected from impact.

At the site at which the station is to be set up outside the van, the following steps must be taken:

1. The site for the installation of the station is prepared. Measures are taken to conceal the equipment and operating personnel. 50X1-HUM
2. The mast and antenna are set up in accordance with local conditions.
3. The rack frame is set up.
4. The sections and line board are removed from their carrying cases.
5. The sections are placed in the frame.
6. The cables are connected to the line board and storage batteries.
7. The antenna transmission lines are connected to the transmitter and receiver.
8. The microtelephone operator's set is connected to the telephone section.
9. The station is switched on, the working frequencies are set, communication is established and the channels are adjusted.
10. The connecting lines are connected to the proper terminals of the line board and the channel is placed in operation.

When establishing an intermediate station the second half-set is installed alongside the first and they are connected by relay cable W 4. If an equipment half-set of different stations is used, the rack frames must be those of half-set A and B.

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5. On the charging board:
 - place the switch marked АРР-ВЫКЛ.-ГЕН ("BATTERY CHARGER-OFF-GENERATOR") in position АРР ("BATTERY CHARGER");
 - place the switch marked КОИТРОЛЬ ("MONITORING") in position АРР ("BATTERY CHARGER");
 - set the rheostat control marked ВОЗБУЖДЕН. ("EXCITATION") to the extreme left position.
6. Start the motor of the battery charger.
7. Place the switches of the battery groups which are to be charged in position ЗАРЯД ("CHARGE").
8. By means of the excitation rheostat located on the charging board (when charging from a PES-0.75 battery charger) or on the control panel of the charger (when using an AB-1-P/30 battery charger), set the generator voltage to provide for normal charging current in the battery group in the most discharged condition.

The charging current is checked by means of an ammeter connected to either group by means of the switch marked КОТРОЛЬ ("MONITORING").

The number of storage battery groups which may be connected for normal charging must not exceed two. If a greater number of groups is connected, two battery chargers are used, in which case cable 11 must be disconnected at one of the charging boards. Normal battery charging continues for seven hours.

NOTE: 1. The storage batteries may be charged with the caps in place. The caps are so designed as to permit the gases liberated during the charging to escape from the batteries and to prevent spilling of the electrolyte.

2. It is forbidden to approach the storage batteries with an open flame while they are charging.

When charging operation has been completed the following steps must be taken:

1. The motor is stopped and the tap of the gasoline tank is closed.
2. The switch marked АП-ВМЖ-ГЕ ("BATTERY CHARGER-OFF-GENERATOR") on the charging board is placed in position В К ("OFF").
3. The switches of the storage battery groups are shifted from position 3А ("CHARGE") to position ВМЖ ("OFF").
4. The cable of the battery charger is disconnected from the recess, rolled and placed on the charger.
5. The charger is covered with its case.
6. The ventilation covers of the battery compartments are closed.

Charging the Batteries from the G-74 Generator

The supplementary G-74 generator permits the simultaneous charging of not more than four normally discharged battery groups with a "fast" charge current of 22.5 amperes in 4.5 hours. The current may be lowered as the batteries are charged.

The G-74 generator is designed to charge storage batteries while the truck is in motion; however, in the case of extreme necessity, it may also be used for battery charging with the station operating from a fixed position.

Batteries are charged by means of the G-74 generator in the following order:

1. Before charging the batteries, open the ventilation covers of the battery compartments.

2. On the charging board:

- set the switch marked АП-ВМЖ-ГЕ ("BATTERY CHARGER-OFF-GENERATOR") in position ГЕ ("GENERATOR");

- set the switch marked КОТРОЛЬ ("MONITORING") in position ГЕ ("GENERATOR").

3. Start the truck engine (when charging from a fixed position).

4. Switch on the G-74 generator. This is accomplished from the driver's cabin and requires that the safety catch be released on the lever for connecting the generator reducer located on the floor of the cabin. Engage the clutch of the truck engine and shift the generator lever to the rear position (drawing it toward the driver). The indicator device on the charging board should indicate a generator voltage of 17-19 volts.

5. Set the switches of the battery groups to be charged in position 3AP~~7~~4 ("CHARGE").

6. Adjust the rpm rate of the truck engine (only when charging the batteries from a fixed position).

It should be borne in mind that the amplitude of the charging current when using the G-74 generator does not change despite wide variations in the rpm rate of the engine. This feature of the charging system makes it possible to charge storage batteries at practically any truck speeds when in motion. When parked, on the other hand, charging operations must be carried out at the minimum engine idling speed capable of providing the necessary charging current.

15.

Checking the Operational Readiness of the Station
Care of the Equipment

When operating a station it is necessary:

- to check the voltage in the mains or from the storage batteries;
- to prevent the accumulation of dust and dirt in the equipment and in the truck van;
- to protect the equipment systems from falling and concussion during repair and removal from the van;
- to handle carefully the connecting and repair cables, keeping them always in the proper operating condition;
- to see to it that the mast joints are not dropped when setting up and taking down the antenna;
- to avoid bending of the antenna dipoles;
- to keep the plugs for the antenna and HF cables free of dirt and moisture;
- to handle the transmission lines with care when setting up and taking down the antenna, particularly in winter conditions, avoiding any sharp bends in these lines;

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- to protect the antennas from falling during and after their erection, by seeing to it that the mast guys are fixed securely to the ground pegs;
- to regularly check the reliability of the mast once set up, particularly in windy and damp weather;

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In position 4 the indicator arrow is deflected only when the crystal calibrator is switched on. In position 6 the arrow is deflected by the indicated number of divisions only when the AFC is switched off. If the AFC is switched on, deflection of the indicator arrow will occur only if the receiver is precisely tuned to the frequency of the transmitter.

NOTE: The transceiver tubes and transmitter output are checked on fixed frequency 21.

4. Check the tubes of the transmitter. For this purpose the left-hand switch of the indicator device is set in position ПЕР ("TRANSMITTER"), while the right-hand switch is run through all of its positions from 1 to 6 successively (around the outer circle of numbers). If the tubes are operating properly, at each position the indicator arrow should also show a deflection of 100 ± 20 divisions (colored sector). In position 5, with the crystal calibrator switched on, the indicator arrow will not deflect.

5. Check the feed voltage and currents for the tubes of the telephone channel section. This requires that the switch of the indicator device on this section be placed alternately in position 160, П4, П2 and П1. If the tubes are operating properly, the indicator arrow should show an excursion of 100 ± 20 divisions (colored sector).

6. Check the feed voltages and currents for the tubes of the telegraph channel section. This requires that the switch of the indicator device on this section be placed alternately in position 1-2, +160v, 3-4. If the tubes are operating properly, the indicator arrow should show an excursion of 0.5 ± 0.1 divisions (colored sector).

Checking the Transmitter Output

The transmitter output is checked in the following manner:

1. Connect a dummy antenna to the transmitter output.
2. Set the left-hand switch of the indicator device in position Вых. ПЕР ("TRANSMITTER OUTPUT").
3. Switch on the transmitter. If the power supply voltage is normal, the indicator arrow should be located within the colored sector as the transmitter is tuned over the band.

Checking the Transmitter Modulation

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Transmitter modulation is checked in the following manner:

1. Set the left-hand switch of the indicator device on the transceiver section in position BX.0EP ("TRANSMITTER INPUT").
2. Set the speech key of one of the telephone channels in position P. KAH ("RADIO CHANNEL").
3. Set the ringing key in position BM3 ("CALL") or C. BM3 ("SERVICE CALL"). The indicator arrow should deflect. The arrow should also deflect when blowing into the microphone of the operator's handset.
4. In the same fashion check the transmitter modulation over the other telephone channel.
5. Check the transmitter modulation from the telegraph channels. This is done in the following order:
 - switch on the telegraph channel power supply;
 - set the operating mode switch in position OKOH ("TERMINAL");
 - set the operation selecting switch in position "-" and then in position "+". With the switch in both positions there should be a deflection of the indicator needle on the transceiver section.

Checking the Operation of the Receiver

The operation of the receiver is checked in the following order:

1. Switch on the station.
2. Set the speech key of the first or second telephone channel in position P. KAH ("RADIO CHANNEL"). Noise should be audible in the earphones of the operator's set.
3. With the indicator switch on the telephone channel section at position Y, the indicator arrow should be deflected, indicating the presence of noise at the receiver output.
4. Switch on the crystal calibrator. This requires that switch BMK1-KA.7M6P ("OFF-CALIBRATOR") be placed in position KAJM6P ("CALIBRATOR"), at which point the noises in the earphones should cease.
5. Check the presence of beats (a tone of varying frequency) in the first telephone channel with the receiver tuned to one of the fixed frequencies 57, 101, or 145.

Checking Calibration of the Receiver and Correcting the
First Receiver Heterodyne

The receiver calibration is checked each time the tube of the first heterodyne (J15) and the frequency control unit (J16) is replaced, and also during periodic inspections of the station. Calibration accuracy is checked over the first telephone channel at rated power supply voltage (12 volts in the case of battery power and 127 volts in the case of a-c mains power) after the station has been allowed to warm up for no less than 3-4 hours with the crystal calibrator switched on.

The receiver calibration is checked and corrected, with the antenna transmission line disconnected, on one of the reference frequencies. Fixed frequencies 57, 101 and 145 are reference frequencies.

The following is the procedure for checking the calibration of the receiver:

1. Set one of the fixed frequencies 57, 101 or 145, on the dial of the receiver.
2. Disconnect the automatic frequency control of the receiver.
3. Set the speech key of the first telephone channel in position P. KAH ("RADIO CHANNEL"), and the single-channel operating switch in position Q4HOK ("SINGLE CHANNEL").

The presence of a tone in the first telephone channel will indicate that the calibration inaccuracy does not exceed 2.7 kg and is of a frequency equal to the frequency of the tone. No frequency correction is required in this case. If no tone is audible in the earphones of the operator's set, this indicates either accurate calibration or, on the contrary, a great discrepancy in calibration. This may be easily seen by turning the receiver control marked BOJHA ("WAVELENGTH"). If, when the control is turned continuously to the right and left of the tuning position, a tone is heard, beginning with the lower frequencies, this indicates precise calibration of the receiver and no frequency correction is required. If, on the other hand, no tone is audible in the earphones, then detuning must be gradually increased by turning the same control to the right or left until a tone is heard at the channel output. The presence of a tone away from the point of accurate receiver tuning indicates mistuning of the receiver, in which case frequency correction is required.

Receiver frequency correction necessitates the following steps:

1. Take note from which side of the reference frequency the tone is detected (the side of a higher or lower fixed frequency number). Unscrew from the casing the stopper marked JET ("HETERODYNE") on the right side of the transceiver section for access to the trimmer.
2. Accurately set the fixed reference frequency on the dial of the receiver.
3. By turning the shaft of the trimmer through the opening in the side panel of the transceiver section, achieve a zero beat at the output of the first telephone channel. If the zero beat is detected from the side of the lower frequency numbers, turn the trimmer shaft in a clockwise direction.

4. Check the accuracy of calibration on the other reference frequency of the receiver. Receiver calibration accuracy on these frequencies should be within the norm.

Checking the Calibration of the Transmitter and Correcting the
Frequency of the Master Oscillator

The transmitter calibration is checked each time the tube of the master oscillator (M3) and the frequency modulator (M4) is replaced, and also during periodic inspections of the station. Calibration accuracy is checked at rated power supply voltage after the station has been allowed to warm up for no less than 3-4 hours with the crystal calibrator switched on. The transmitter calibration is checked in the following fashion:

1. Receiver and transmitter are terminated in dummy antennas.
2. The speech key of the first telephone channel is set in position P. KAH ("RADIO CHANNEL"), and the single-channel operating switch in position OAHOK ("SINGLE CHANNEL").
3. The receiver is accurately tuned to zero beat on one of the fixed reference frequencies (57, 101 or 145).
4. A fixed frequency corresponding to the tuning frequency of the receiver is set on the transmitter dial.

The single-channel operation selecting switch is set in position OKOH ("TERMINAL"). If a beat tone is heard at the output of the first telephone channel, transmitter calibration is within the norm and frequency correction is not required. By slowly turning the transmitter control marked BOJHA ("WAVELENGTH") to the right and left, it is ascertained that the zero beats are derived from the transmitter signal.

If no tone is audible at the output of the first telephone channel and the zero beat is detected when the receiver is detuned, this indicates an inaccuracy of calibration and frequency correction is necessary. If the zero beat ceases to be audible when the transmitter is precisely tuned to the fixed reference frequency, the signal from the transmitter at the receiver input must be reduced by changing the coupling between their dummy antennas.

The transmitter frequency is corrected in the following order:

1. Set the receiver accurately to zero beat on one of fixed frequencies 57, 101 or 105.
2. Accurately set on the dial of the transmitter a fixed frequency corresponding to the tuning frequency of the receiver.
3. Unscrew from the casing the stopper marked 3.F. on the left wall of the transceiver section and achieve a zero beat by turning the trimmer shaft through the opening.
4. Check the transmitter calibration accuracy on the other reference frequencies. Calibration accuracy on these frequencies should be within the norm.

Checking the Operation of the Automatic Frequency Control
(AFC) of the Receiver and its Adjustment

The operation of the automatic frequency control (AFC) is checked at rated power supply voltages on fixed reference frequencies (57, 101, 145) after heating for not less than 3-4 hours with the crystal calibrator switched on. The check is made in the following order:

1. Set one of the fixed reference frequencies, 57, 101 or 145, on the dial of the receiver.
2. Place the left-hand switch of the indicator device of the transceiver section in position ПР, and the right-hand switch in position 6 along the inner circle of numbers.
3. Place the speech key of the first telephone channel in position P. KAH ("RADIO CHANNEL").
4. Tune for zero beat at the output of the telephone channel by slowly turning the receiver control marked БО HA ("WAVELENGTH").
5. Switch on the AFC (by setting switch АМ-ВЫКЛ ("AFC-OFF") in position АМ ("AFC")). If the tone in the earphones of the operator's set does not change when the AFC is switched on, this indicates proper tuning of the AFC.

If the AFC is properly adjusted, the indicator readings (when checking the current of tube Л6 of the receiver) should not change when the AFC is switched on and off. If this is not the case, the AFC must be adjusted.

To adjust the AFC, unscrew from the casing the stopper marked АМ (AFC) on the right wall of the transceiver section and by turning the potentiometer through the opening cause the current of tube Л6 to remain constant when switching on and off the AFC. This should cause no change in the tone at the output of the telephone channel.

Checking the Condition of the Antenna-Transmission Line Unit

The condition of the antenna-transmission line unit is checked by operating a transmitter, with an antenna connected to its output, against the receiver of the same half-set, to the input of which there is also attached an antenna.

The following steps are necessary when checking the condition of the antenna-transmission line units:

1. Set the left-hand switch of the indicator device of the transceiver section in position АНТ ("ANTENNA").
2. Set the same fixed frequency on the dials of the receiver and transmitter. The indicator arrow should deflect. If it does not, turn the control handle marked БО HA ("WAVELENGTH") of the receiver to the left or right within 2-3 fixed frequencies until a reading of the indicator device is obtained. If even in this case the indicator arrow fails to move (with the transmitter and receiver in proper operating condition), this indicates a defect in the antenna-transmission line system of the transmitter or receiver.

Deflection of the indicator arrow when the receiver tuning differs by more than three fixed frequencies from the tuning of the transmitter, indicates a defect in the high-frequency circuits of the HF amplifier of the receiver. In this case the station requires general overhauling.

Checking the Telegraph Channels

Checking Telegraph Channels between Terminal Stations of the Radio Link

The telegraph channels are checked in both directions between terminal stations of a link, after the telephone channels have been adjusted, in the following manner:

1. Connect the telegraph channel to be tested.
2. Set switch OKOH.-ПРОВО.-РЕТР ("TERMINAL-CHECK-RELAY") of the telegraph channel in position OKOH ("TERMINAL").
3. Set the switch of the indicator device on the telegraph channel section in position ИТ ("1st TELEGRAPH") or ИИТ ("2nd TELEGRAPH").
4. On the transceiver section set the left-hand switch of the indicator device in position ВХ.ВЕР. ("TRANSMITTER INPUT").
5. Set the operation selecting switch of the telegraph channel in position "+". At this point, the indicator arrow of the transceiver section at the first station should move to the division corresponding to the table of deviations. At the other terminal station of the link, the indicator arrow on the telegraph channel section should be deflected to the right.
6. Set the operation selecting switch of the telegraph channel in position "-". At the other terminal station the indicator arrow on the telegraph channel section should move to the left.

In this way the condition of the entire telegraph channel system is checked, with the exception of the line circuits. The condition of the latter may be judged by the presence of incoming and outgoing currents when working with P-100 telegraph equipment or when working in duplex with ST-35 equipment, and by the presence of an incoming current when working in simplex with ST-35 equipment.

Checking the Telegraph Channels "Against Themselves"

The telegraph channels may be checked "against themselves" over low frequency both during operation of the station without disrupting communication over the telephone channels, as well as with the station operating in the standby reception mode.

The telegraph channels are checked in the following manner:

1. Place the half-set in the standby reception mode (if the station is not communicating).
2. Switch on the power supply for the telegraph channel to be checked.

3. Place the switch OKOH-MPOB-PETP ("TERMINAL-CHECK-RELAY") in position MPOB ("CHECK").
4. Place the indicator switch in position IT ("1st TELEGRAPH") or IIT ("2nd TELEGRAPH").
5. Place the operation selecting switch of the channel in position "+". The arrow of the indicator device should move to the right.
6. Place the operation selecting switch of the channel in position "-". The arrow of the indicator device should move to the left.

In this case, just as when checking the channels between terminal stations of a link, the condition of the transmitting and receiving sections of the telegraph channel system of the station is checked, with the exception of the line circuits.

Checking the Operation of the Station "Against Itself"

By the operation of a station "against itself" is understood the operation of the transmitter of one half-set against the receiver of another half-set, or the operation of a transmitter against the receiver of the same half-set of a station.

With two half-sets in operation, an "against itself" check is made in the following order:

1. Place both half-sets in the standby mode of operation.
2. Tune the receiver of half-set A to the transmitter of half-set B, and the receiver of half-set B to the transmitter of half-set A.
3. Connect to the output of the transmitters and to the input of the receivers the transmission lines from the antenna or dummy antenna.
4. Switch on the transmitter.
5. Check for noise suppression in the telephone channels. If it has been suppressed, check for calling and speaking over the telephone channels in both directions.
6. Check the condition of the antenna-transmission line units and the tracking of the high-frequency circuits of the receiver.
7. Check the level at the receiver output. For this purpose:
 - on the telephone channel section of one half-set, place the switch of the indicator device in position Y;
 - send a transmission test level over one of the telephone channels from the other half-set.

8. The indicator arrow on the first half-set should move to the colored sector.

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9. Adjust the telephone and telegraph channels in both directions.

10. Check calling and speaking over the radio link channels from the telephone set available at the station. For this purpose, connect the telephone set to terminals 1-2 (5-6) of the line board first of one, then of the other half-set.

In the event that one of the half-sets is connected and is communicating, the condition of the other half-set may be checked by operating the transmitter against the receiver of that half-set.

The check is made in the following order:

1. Connect to the output of the transmitter and to the input of the receiver the antennas or their equivalents.

2. Connect the half-set and set the same working frequency on the transmitter and receiver (the fixed frequencies used in the check must be selected so as to create no interference to the half-set which is communicating).

3. Check noise suppression at the output of the telephone channels.

4. Set the operation selecting switch of the first (second) telephone channel to position 4 T01, the speech key of the channel to position P. KAH ("RADIO CHANNEL") and the ringing key to position B03 ("CALL") or CA. B03. ("SERVICE CALL"). In both cases the tone of the ringing frequency should be heard in the earphones of the operator's set.

5. Connect the telephone set to terminals 1-2 (5-6) of the line board and place the monitoring key in position I (II). Conversation sent from the telephone instrument should be audible in the earphones of the operator's set.

16.

Possible Defects in the Equipment and Their Elimination

1. Possible Defects in the Transmitter and Their Elimination

<u>No.</u>	<u>Symptom of the Defect</u>	<u>Cause</u>	<u>Elimination</u>
1	When checking the tubes of the transmitter the arrow of the indicator device of the transceiver section fails to move.	Failure of the particular tube.	Replace the tube in question. If after replacement of the tube the indicator arrow fails to move, the stage should be checked for agreement of voltages and resistances with those indicated in the tables (Appendix 3).

<u>No.</u>	<u>Symptom of the Defect</u>	<u>Cause</u>	<u>Elimination</u>
2	No +170v and -25v voltage.	1. When powered by storage batteries: a) burn-out of left fuse on 5a on transceiver section; b) failure of triode $\Delta 4B$ in the feed element. 2. Failure of switch B4 PA5, ΔEK ("WORK-STANDBY").	a) Replace fuse. If fuse burns out again, check pertinent circuits. b) Replace triode. 2. Replace switch.
3	+170v voltage absent; -25v voltage present.	a) Failure of electrolytic capacitor C2 or C3. b) Failure of rectifier bridge $\Delta 1$.	a) Replace defective electrolytic capacitor. b) Replace germanium diodes of rectifier bridge. Before switching on station check 170v circuit for short-circuit to chassis.
4	-25v voltage absent; +170v voltage present.	a) Failure of electrolytic capacitor C4 or C5. b) Failure of rectifier bridge $\Delta 2$.	a) Replace defective electrolytic capacitor. b) Replace germanium diodes of rectifier bridge. Before switching on station check -25v bias circuit of the control grid of tube 1 for short-circuit to chassis.
5	No voltage on plates and screen grids of tubes. Voltage present when measured on block of feed element between leads +170v and Common.	Break in wiring.	Locate break and eliminate it, after identifying proper circuit.
6	Transmitter fails to emit oscillations. Transmitter operation not received on receiver of half-set.	Failure of tube $\Delta 1$.	Replace tube $\Delta 1$.
7	Plate voltage not fed to tube $\Delta 5$.	Switch B5 KA ΔMS P-BYK Δ ("CALIBRATOR-OFF").	Replace switch after first feeding +170 volts to contact 10 of block $\Delta 3$ directly and making sure that it reaches tube plate.

2. Possible Defects in the Receiver and Their Elimination

<u>No.</u>	<u>Symptom of the Defect</u>	<u>Cause</u>	<u>Elimination</u>
1	When checking the tubes of the receiver, the arrow of the indicator device of the transceiver section fails to move.	Failure of the particular tube.	Replace the tube in question. If after replacement of the tube the indicator arrow fails to move, the stage should be checked for agreement of voltages and resistances with those indicated in the tables (Appendix 3).
2	Absence of +160v and 60v feed voltage when operating on storage batteries.	Burn-out of right hand fuse on transceiver section.	Replace fuse. If fuse burns out again, check pertinent circuits.
3	Absence of +160v feed voltage; 60v voltage present.	a) Failure of electrolytic capacitor C2 or C3. b) Failure of rectifier bridge A1.	a) Replace defective electrolytic capacitor. b) Replace germanium diodes of rectifier bridge. Before switching on station check +160v circuit for short-circuit to chassis.
4	Absence of 60v voltage; +160v voltage present.	a) Failure of electrolytic capacitor C4 or C5. b) Failure of rectifier bridge A2.	a) Replace defective electrolytic capacitor. b) Replace diodes of rectifier bridge.
5	Failure of crystal calibrator to operate. Indicator arrow moves beyond sector when checking tube 4. No beat heard on fixed reference frequencies 57, 101 and 145.	a) Break in circuit of crystal of crystal calibrator. b) Failure of crystal of crystal calibrator.	a) Eliminate break.
6	AFC fails to operate.	a) Failure of tube. b) Failure of switch AN1-BUKA ("AFC-OFF"). c) Failure of potentiometer R88.	a) Replace tube. b) Replace switch. c) Replace potentiometer.

<u>No.</u>	<u>Symptom of the Defect</u>	<u>Cause</u>	<u>Elimination</u>
7	When receiving a transmission test level during an "against itself" check of the station, the arrow of the indicator on the telephone channel section does not reach the sector with the indicator switch in position "Y". AFC, meanwhile, operates.	a) Low gain by LF amplifier (J13). b) Failure of tube J13, in which case indicator arrow will not move.	a) By revolving shaft of potentiometer R75 located on left side wall of transceiver, set indicator device arrow on telephone channel section to center of sector. If this is unsuccessful, replace tube J13. b) Replace tube J13.

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6	When receiving operational call, the tone of the ringing frequency is audible, but the pole changer fails to operate.	a) Failure of electrolytic capacitor C80 (C82). b) Defective relay P3 (P10).	a) Replace capacitor. b) Adjust or replace relay.
7	When call comes in from a switchboard, the bell rings but the signal lamp fails to flash.	Burnt out signal lamp JH2 (JH4).	Replace lamp.
8	When call comes in from switchboard, signal lamp fails to flash and bell fails to ring.	a) Break in winding of choke A P1 (A P2). b) Failure of rectifier bridge A1 (A7). c) Defective relay P1 (P8).	a) Replace choke. b) Replace rectifier bridge. c) Adjust or replace relay.
9	When call comes in from radio channel, the bell rings (pole changer operates), but the signal lamp fails to flash.	Burnt out signal lamp JH1 (JH3).	Replace lamp.
10	Signal from station to switchboard and from switchboard to station fails to pass over one of the channels.	a) Failure of one of the fuses of the channel in question on the line board. b) Broken contact in key K1 (K4).	a) Replace fuse. b) Bend contact blades of key.

<u>No.</u>	<u>Symptom of the Defect</u>	<u>Cause</u>	<u>Elimination</u>
11	No voltage adjustment at output of telephone channel.	Failure of resistor R20 (R36) in LF amplifier.	Replace resistor.
12	No plate voltage on tube $\mathcal{M}1$ ($\mathcal{M}2$).	a) Break in winding 1-2 of transformer Tp3. b) Break in winding 1-2 of inductance L1 or L2.	a) Replace transformer. b) Replace inductance.
13	No voltage on screen grid of tube $\mathcal{M}2$.	a) Shorted capacitor C12. b) Shorted capacitor C11 and burnt out resistor R17.	a) Replace capacitor. b) Replace capacitor and resistor.
14	No plate voltage on tube $\mathcal{M}3$.	a) Shorted capacitor C41. b) Break in winding 1-2 of transformer Tp9.	a) Replace capacitor. b) Replace transformer.
15	No voltage on screen grid of tube $\mathcal{M}3$.	Shorted capacitor C42 and burnt out resistor R43.	Replace capacitor and resistor.
16	No plate voltage on tube $\mathcal{M}4$.	Break in winding of inductance L21.	Replace inductance.
17	No voltage on screen grid of tube $\mathcal{M}4$.	a) Shorted capacitor C37. b) Shorted capacitor C36 and burnt out resistor R50.	a) Replace capacitor. b) Replace capacitor and resistor.

4. Possible Defects in the Telegraph Channel Section and Their Elimination

1	No reception (transmission) over the telegraph channel.	Failure of receiving (transmitting) relay type RP-4.	Replace receiving (transmitting) relay.
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<u>No.</u>	<u>Symptom of the Defect</u>	<u>Cause</u>	<u>Elimination</u>
2	No transmission over the telegraph channel in the single-wire simplex mode (1WP) and in the two-wire simplex mode (2WP). No line current when telegraph set is switched on. Telegraph channel operates bipolar (Baudot) mode.	a) Failure of diode $\Delta 9$ ($\Delta 11$) or $\Delta 10$ ($\Delta 12$). b) Voltage not being fed to field winding of transmitting relay of telegraph channel. c) Failure of one of the windings of transmitting relay P2 (P4).	a) Change polarity of line battery. b) Check circuit over which voltage is fed to field winding (see Section 7, Chapter 2). c) Replace relay.
3	No reception over the telegraph channel in the bipolar mode (Baudot).	± 60 volts not fed to contacts of receiving relay.	Check circuits over which the +60v voltage is fed to contacts of receiving relay (see Section 7, Chapter 2).
4	No reception over the telegraph channel in the two-wire simplex mode (2WP) and in the bipolar mode (Baudot).	Burnt out resistor R28 (R62).	Replace resistor.
5	When telegraph channel adjusting device is connected through the line board, there is no work over the telegraph channel. When this device is connected through the jack on the telegraph channel section, operation is normal.	Failure of the pertinent fuse on the line board.	Replace fuse.
6	No +60v voltage from the line circuit element.	With power from storage batteries: a) Burnt out fuse on telegraph channel section. b) Failure of triode. c) Failure of rectifier bridge $\Delta 1$ or $\Delta 2$, in which case either the +60v voltage alone or the -60v voltage alone will be absent.	a) Replace fuse. If fuse burns out again, check pertinent circuits. b) Replace triodes. c) Replace pertinent rectifier bridge.

<u>No.</u>	<u>Symptom of the Defect</u>	<u>Cause</u>	<u>Elimination</u>
7	When checking the tubes, the arrow of the indicator device takes a position approximately in the center between the colored sector and the neutral position.	Failure of the pertinent tubes of the telegraph channel. If there is no transmitter frequency deviation from the telegraph channel, the failure is in the oscillator tube.	Replace pertinent tube.
8	No plate voltage on tube J12 (J14).	Burnt out resistor R15 (R48).	Replace resistor.
9	No voltage on screen grid of tube J11 (J3).	a) Shorted capacitor C21 (C45). b) Shorted capacitor C7 (C31) and burnt out resistor R5 (R37).	a) Replace capacitor. b) Replace capacitor and resistor.
5. Other Possible Defects in the Equipment and Their Elimination			
1	With a battery group connected on "discharge" the automatic mains protection operates (switch ABC-10 is set at position BUK ("OFF")).	A short in the +12v circuit in the charging board or equipment.	Check the pertinent circuits.
2	With the batteries on "CHARGE" the ammeter on the charging board gives no reading (engine revolutions are normal).	Failure of the reverse current relay to operate from low generator voltage.	Raise generator voltage by increasing excitation current.
3	No voltage from generator GSK-1500.	Generator not excited. Break in excitation circuit or generator demagnetized.	Determine and eliminate defect.
4	Sharp change in generator voltage and charging current when charging storage batteries.	Arcing of generator brushes due to dirt in commutator or loose fit of brushes.	Clean commutator, wipe brushes and adjust brush mechanism.

<u>No.</u>	<u>Symptom of the Defect</u>	<u>Cause</u>	<u>Elimination</u>
5	No power from engine of battery charger.	a) Obstruction of fuel line and carburetor. b) Burnt out spark plug terminals. Burnt out fuse #p9.	a) Clean fuel line and carburetor. b) Replace spark plug. Replace fuse. In the event fuse burns out again, check pertinent (TN: TEXT MISSING).
6	Failure of signal lamp #H1 on mains board to flash.	TN: TEXT MISSING	TN: TEXT MISSING
7	One of the signal lamps on the mains board flashes (lamp #H1 should light when mains power is connected).	Pertinent fuse has burnt out.	Replace fuse. If fuse burns out again, check pertinent circuits.

CHAPTER IV

MEASURING THE BASIC PARAMETERS OF THE STATION

1.

Measuring the Transmitter Output

The transmitter output (power) is measured with the transmitter operating over a dummy antenna. The voltage of the primary power sources must stand at the rated values.

Transmitter output is measured by determining the HF voltage on the dummy antenna by means of a type VSK-7, VLU-2 tube voltmeter or any other high-frequency a-c tube-type voltmeter.

Power is determined by the formula:

$$P = \frac{V^2}{R}$$

where: P is the transmitter power in watts,
V is the measured voltage in volts,
R is the resistance (75 ohms) of the dummy antenna.

For the measurement of HF voltage on the dummy antenna, the screen of the latter has a special opening. When making a test, tip "B" of the voltmeter probe must be passed through this opening and brought into contact with the internal rod of the dummy antenna, while tip "G" is pressed firmly against the shield of the antenna. Long conductors may not be used when measuring the HF voltage.

Transmitter power is tested at three points on the band. (on the lower, medium and upper frequencies of the band). In the same manner the power at the output of the power amplification section may be measured, using a 75-ohm dummy antenna with a permissible dissipated power of not less than 25 watts.

The power supplied by the transmitter to the antenna (or its equivalent) may also be measured by means of type IMR-4 or IPM-303 through power meters. The IPM-303 instrument also permits measurement of the power delivered by the power amplification section to the antenna (or its equivalent).

These devices measure the incident power P_{inc} fed from the transmitter (power amplification section) to the load (the antenna or its equivalent) and the reflected power P_{ref} from the load.

The through power to the load equals the difference of the incident and reflected powers: $P_{thr} = P_{inc} - P_{ref}$.

A simpler method of measuring the power delivered by the transmitter to a 75-ohm load is to measure this power by means of a type ISM-2 medium-power meter. The input of this instrument represents a 75-ohm load. If the power delivered by the transmitter is less than 2.5 watts and there is significant non-uniformity in the band, then the output circuit of the transformer must be tuned.

The output circuit of the transformer is tuned in the following sequence:

1. Set the highest frequency of the band on the transmitter.
2. Remove the stopper marked БМХ. КОЕЧР. ("OUTPUT CIRCUIT") on the forward panel of the transceiver section.
3. Set the switches of the indicator device on the transceiver section in the following positions:
 - the left-hand switch in position "ПЕР" ("TRANSMITTER");
 - the right-hand switch in position 1 along the outer circle of letters.
4. Connect the dummy antenna to the transmitter output and measure the power as described above.

By turning the shaft of the trimmer, adjust for maximum power at the transmitter output. In so doing the arrow of the transceiver section indicator device should be located in the colored sector.

2.

Measuring the Efficiency of the Transmission Line

The efficiency of the transmission line is determined by the ratio of the output power P2 of the loaded transmission line to the input power P1.

To determine the efficiency of a transmission line when measuring power by means of an ISM-2 instrument or with a tube-type voltmeter, proceed as follows:

1. Determine the power P1 fed by the transmitter directly to the dummy antenna (measuring with an ISM-2 instrument), or determine the HF voltage V1 at the dummy antenna connected to the transmitter output (measuring with a tube-type voltmeter), as described above.

2. Determine the power P2 (by means of an ISM-2 instrument) or the voltage V2 (by means of a tube-type voltmeter) at the antenna dummy connected to the transmitter through the transmission line to be tested.

3. Determine, on the basis of the data so obtained, the efficiency of the transmission line according to the formula:

$$\text{Eff.}\% = \frac{P_2}{P_1} \times 100$$

$$\text{or Eff.}\% = \frac{(V_2)^2}{V_1^2} \times 100$$

To determine the efficiency of a transmission line when measuring power by means of a through-power meter, proceed as follows: 50X1-HUM

1. Measure the through power P_{thr1} at the beginning of the transmission line. For this purpose, the through-power meter is connected between the transmitter output and the transmission line to be tested, terminated at its end in a dummy antenna.
2. Measure the through power P_{thr2} at the end of the line. For this purpose, the transmission line to be tested is connected at one end to the transmitter output and at the other to the dummy antenna over the through-power meter.
3. Determine, on the basis of the data so obtained, the efficiency of the transmission line according to the formula:

$$Eff. = \frac{P_{thr2}}{P_{thr1}}$$

The efficiency of a transmission line consisting of a type PK-1 coaxial cable 25 meters in length must be not less than 64%.

3.

Measuring the Traveling-Wave Ratio of the Antenna

The traveling-wave ratio (TWR) of the antennas of the R-401M station may be measured by means of a 75-ohm coaxial test line not less than 2.5 meters in length or by means of a type IMR-4 or IPM-303 through-current meter.

If these instruments are not available, it is possible to use as a test line a section of type RK-1 or RK-3 coaxial cable having openings in the outer braiding, through which a VKS-7 or VLU-2 tube-type voltmeter can be connected to measure the voltage between the internal conductor and the external braiding of the cable. The length of this cable section must not be less than 2.5 meters and the apertures in it must reoccur every 10 centimeters. The cable must have at its ends standard HF plugs similar to those of the station.

The traveling-wave ratio is determined, when using a test line or the cable section described above, according to the following formula:

$$TWR = \frac{V_{min.}}{V_{max.}},$$

where: $V_{min.}$ is the minimum voltage along the test line;
 $V_{max.}$ is the maximum voltage along the test line.

The simplest method for measuring the traveling-wave ratio of the station antennas is to employ a through-power meter. For this purpose, at the beginning of the transmission line a measurement is made of the incident power P_{inc} and the reflected power P_{ref} .

According to this data, the reflectance is calculated:

$$R = \sqrt{\frac{P_{\text{ref.}}}{P_{\text{inc.}}}}$$

The standing wave ratio is calculated by the formula:

$$\text{TWR} = \frac{1-R}{1+R}$$

When measuring the traveling-wave ratio, the test instrument (coaxial test line or through-power meter) is connected between the transmitter output and the standard antenna transmission line, at the output of which is connected the antenna to be tested (Yagi or whip).

4.

Measuring the Attenuation of the Branches of the Frequency Filter Section

The attenuation introduced by the left and right branches of the frequency filter section as the signal travels in the forward direction (from the transmitter to the antenna) may be measured by means of a type VKS-7 or VLU-2 tube voltmeter, an IMR-4 or IPM-303 through-power meter or an ISM-2 medium-power meter.

For this purpose, the frequency filter section is connected for operation in the manner described in Section 11, Chapter 3 of this Guide. When measuring attenuation, in place of the actual antenna of the station a dummy is connected to the frequency filter section. By means of the tube voltmeter a reading is taken of voltage V_2 on the dummy antenna. If a through-power meter or a medium-power meter is used for the test, a reading is made of the power P_2 flowing into the dummy antenna. The frequency filter section is then disconnected from the transmitter and the dummy antenna is connected to the output of the transmitter. A reading is taken of voltage V_1 on the dummy antenna or the power P_1 flowing into it.

When measuring with a tube voltmeter, the attenuation (in decibels) introduced by a frequency filter section branch is determined by the formula:

$$\text{Att.} = 20 \text{ units } \frac{V_2}{V_1} .$$

When conducting the measurements by means of a through-power meter, the attenuation (in decibels) is determined by the formula:

$$\text{Att.} = 10 \text{ units } \frac{P_2}{P_1} .$$

The attenuation introduced by the left and right branches of the frequency filter section is measured at three points of each half of the band. This attenuation must not be more than 3 decibels.

5.

Measuring the Frequency Deviation of the Transmitter

The transmitter frequency deviation is measured by means of an IChM-5 FM meter or any other similar instrument in the following manner:

1. Set the frequency deviation of the transmitter according to the table, as discussed in Section 5, Chapter 3 of this Guide.

2. Tune the IChM-5 frequency-modulation meter to the transmitter frequency.

3. To measure the transmitter frequency deviation from telephone channel signals proceed as follows:

- connect to the input of the telephone channel the tone generator or test console;

- feed from the tone generator (test console) a voltage of 800-cycles frequency and rated input level;

- determine, according to the FM meter, the transmitter frequency deviation which should lie between 6-9 kc.

4. To measure the transmitter frequency deviation from telegraph channel signals, proceed as follows:

- switch on the telegraph channel;

- set the operation selecting switch of the channel in position OKOH ("TERMINAL");

- set the telegraph channel operation selecting switch in position "+" and determine the transmitter frequency deviation by instrument IChM-5;

- shift the telegraph channel operation selecting switch to position "-" and determine transmitter frequency deviation by instrument IChM-5.

The transmitter frequency deviation from the telegraph channels should lie between 3 - 5.0 kc.

6.

Measuring the Sensitivity of the Receiver

Receiver sensitivity is measured, both over the first and second telephone channels, at three points of the band by means of standard signal generator type GSS-17, GSS-7 or SG-1 and a type UNP-2* noise voltage indicator in the following manner:

* If a UNP-2 noise voltage indicator is not available, the test may be made by means of an LV9-2 tube voltmeter, with the noise voltage at the telephone channel output reaching 7.5 mv.

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1. Set on the receiver the fixed frequency on which receiver sensitivity is to be measured and disconnect the AFC.
2. Tune the transmitter of the second half-set to this frequency and adjust the telephone channels, having removed relays P Π -5 of the voice-frequency ringing receivers.

The signal level at the telephone channel output (105 mv) should be set on a 620-ohm load according to the tube voltmeter or the UNP-2 tester. After the telephone channels have been adjusted, the transmitter of the second half-set is switched off.

3. Connect to the receiver input the GSS-7 or SG-1 (measurements with the GSS-17 are described below).

4. Feed from the standard signal generator an unmodulated signal having a frequency equal to that to which the receiver is tuned.

5. Set the output voltage of the standard signal generator so that the noise voltage at the telephone channel output equals 5.25 mv. This requires that the standard signal generator be tuned for maximum noise suppression to the receiver tuning frequency. That voltage at the output of the standard signal generator, expressed in microvolts, at which the noise at the telephone channel output equals 5.2 microvolts, will correspond to the receiver sensitivity.

A measurement of sensitivity by means of a standard signal generator with frequency modulation, for example, the GSS-17, is made as follows:

1. Connect to the receiver input the standard signal generator and tune it to the receiver frequency.
2. Connect to the output of the telephone channel, terminated in a 620-ohm load, the UNP-2 or the LV9-2 tube voltmeter.
3. Remove receiving relays P Π -5, send from the standard signal generator a signal modulated by a 1000-cycle frequency with a deviation of 7 kg and set a level of 105 mv at the output of the first telephone channel.

When setting the level over the second telephone channel, the carrier frequency of the standard signal generator is modulated from an external tone generator with a frequency of 6400 cycles.

4. Feed from the standard signal generator an unmodulated signal and set the voltage at its output so that the noise voltage at the telephone channel output equals 5.25 mv. The voltage at the standard signal generator output, expressed in microvolts, at which the noises at the telephone channel output equal 5.25 mv, will correspond to the receiver sensitivity.

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7.

Determining the Error in the Setting of the Working Levels
(Residual Attenuation) in the Telephone Channels According
to the Instruments of the Station

The error in setting the working levels (residual attenuation) in the telephone channels is determined by comparing the readings of the instruments of the station with the readings of the instruments of test console ICh in the following manner:

1. When operating both half-sets of the station "against themselves" or when operating with another station, adjust the telephone channels in both directions.
2. At the receiving end, remove relays P $\bar{n}$ -5 of the ringing receivers. At the transmitting end, feed to the telephone channel input from the test console a voltage having a frequency of 800 cycles and a normal input level.
3. At the receiving end, at the telephone channel output, measure the output level by means of the level indicator of a test console with a 600-ohm output and compare it with the rated output level. The difference will constitute the magnitude of the error in setting the working levels (residual attenuation).

The accuracy in setting the residual attenuation by the instruments of the station in all telephone channel working modes must not be more than ± 0.2 nepers.

A more accurate measurement of the working level setting error (residual attenuation) in the telephone channels of the R-401M radio relay station is possible by means of P-320 test equipment.

8.

Measuring Crosstalk

By crosstalk is understood the interference formed by the seeping of signals from one telephone channel into another.

In the channels of the R-401M radio relay station crosstalk is estimated on the basis of a comparison of the results of psophometric noise measurements in a channel without crosstalk (without modulation of the other channel) and with crosstalk (with the other channel modulated).

Noise in the telegraph channels is measured by a circuit noise meter (psophometer) at the terminals (of the proper telephone channel) of the line board. A UNP-2 noise voltage indicator or any other type of psophometer may be used in the tests.

The noise voltage measured by a psophometer at the output of a telephone channel terminated in a 600-ohm load is called psophometric noise voltage.

Before measurements are made, the psophometer must be adjusted in accordance with the instructions which accompany it. Crosstalk is checked with the station operating "against itself" or with two stations operating in terminal mode at a short distance one from the other.

Before the test is made, the following must be set (see Section 5, Chapter 3 of this Guide);

1. The normal frequency deviation of the transmitter.
2. The normal output levels of the telephone channels.

Noise is measured in the following way. One of the channels is modulated from the tone generator (or from a type ICh test console) by a 1000-cycle frequency with normal input level. The modulating frequency is periodically switched on and off. At the opposite end of the radio link, to the output of the other telephone channel, a 600-ohm psophometer is connected and the noises are measured with and without the modulating frequency present in the other channel. Crosstalk voltage is determined by the formula:

$$V_{\text{cross}} = \sqrt{V_2^2 - V_1^2}$$

where: V_{cross} is the psophometric crosstalk voltage;
 V_2 is the psophometric noise voltage with the modulating frequency present in the other channel;
 V_1 is the psophometric noise voltage with the modulating frequency absent in the other channel.

9.

Measuring Telegraph Distortions

Telegraph distortions in the channels of the station may be accurately measured by means of a stroboscopic telegraph distortion meter. The II-1 instrument, which is part of the P-313 multiplexing equipment, may, for example, be used as a stroboscopic telegraph distortion meter. This same device may be used to estimate the measurement error of the instrument used to adjust the telegraph channels and the transmitting relay.

To measure telegraph distortions it is necessary:

- to adjust the telegraph channel according to the device which is part of the station's equipment;

- to connect to the telegraph channel the stroboscopic telegraph distortion meter (instead of the device supplied with the station) and to measure the distortions in the channel.

The error in the neutral setting of telegraph channels according to the telegraph channel adjusting device, should not exceed 5% with any P -4 relays which meet their technical specifications.

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APPENDIX I

SAFETY INSTRUCTIONS

1. The facility chief is responsible for the observance of all safety rules when working with the station.
2. Persons other than those of the duty shift are forbidden to enter or remain in the van of the truck during communication operations without the permission of the facility chief.
3. The pertinent power supply sources must be disconnected when replacing fuses. When replacing fuses in the battery charging circuits, the battery groups under charge must be disconnected.
4. During repair, check-out of cabled sections and power supply circuits as well as during other operations involving the handling of high-voltage circuits, at least two persons must be in the vehicle in order to lend whatever aid may be required.
5. Rubber gloves must be worn when connecting cable H-4 to the alternating current mains, and this must be done in the presence of a person capable of lending the necessary assistance.
6. The connection of alternating current and operation without preliminary grounding of the vehicle is categorically forbidden.
7. When preparing the electrolyte for charging of storage batteries, the rules outlined in the "Instructions For The Handling Of Nickel-Cadmium Storage Batteries" are to be strictly observed.
8. The engine must be off when refueling. Handling of an open flame and smoking is forbidden when mixing a fuel.
9. Removal of the covering of the engine when the latter is in operation is forbidden.
10. Lowering of the mast without the use of the winch is forbidden.
11. Before setting up the mast, the condition of the guys, hooks and peg rings must be checked.

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APPENDIX 2

INSTRUCTIONS FOR CARRYING OUT
TECHNICAL INSPECTIONS ON THE R-401M STATION

1. Depending on the time limits in which they are conducted and the amount of work involved, the visual inspection and operational tests are broken down into the following categories:
 - a visual inspection before each departure to a new station deployment site;
 - operational test No. 1, made at stations which have been in extended storage in their assigned unit;
 - operational test No. 2, made at stations presently in operation;
 - operational test No. 3, made every six months.
2. The visual inspection is performed personally by the station chief together with the electro-mechanic (the latter is also the driver).
3. Operational tests Nos. 1 and 2 are performed personally and jointly by the platoon commander, sub-unit technician and station chief.
4. Operational test No. 3 is performed by the engineer of the unit (sub-unit), the platoon commander, the sub-unit technician, the station chief and the chief of the repair-test station of the radio relay sub-unit (unit).
5. The visual inspection before each departure to a new station deployment site is performed for the purpose of verifying the reliability of the attachment of racks, sections on racks, end caps on transmission line lead-ins, mast erec-tors, antenna cases, storage batteries and battery chargers as well as the re-maining equipment and accessories of the station.
6. Operational test No. 1 is performed at stations which have been in ex-tended storage in their assigned unit.

An external inspection is made regularly twice a month. In this inspection, attention is paid to the condition of the protective covering on the equipment of the station and to the condition of the antenna transmission line and antenna.

NOTE: If a white film is found on zinc-plated surfaces (zinc hydroxide), it is recommended that the lat-ter be cleaned with a cloth dipped in gasoline, wiped dry and then lubricated with a thin layer of gun oil.

The operation of the station is checked once every two months. This involves an "against itself" operational check of both half-sets (see Section 15, Chapter III of this Guide).

It is also desirable to check the operation of the telegraph channels with ST-35 or Baudot equipment connected. In addition, the operation of the PES-0.75 battery charger and the truck-driven power take-off system should be checked.

The storage batteries are stored and checked in accordance with the "Instructions For The Handling Of Nickel-Cadmium Storage Batteries".

The results of the operational test are entered in the operational log of the station.

7. Operational test No. 2 is conducted not less frequently than once a month at stations which are in operation. In this test a check is made of the external condition of the station, equipment and accessories. Particular attention is directed at the detection of possible corrosion and to the proper condition of the wiring and of the antenna-mast unit.

The test envisages a check of tube operation and proper voltages, the condition of the storage batteries, PES-0.75 battery charger and truck-driven power take-off system. Special attention is directed at the condition of the high-frequency jacks and plugs (connecting elements) and the contact bushings and nuts are tightened by means of a wrench specially designed for HF connections and contained in the tool case of the station and truck. The results of the inspection are entered in the operational log of the station.

8. Operational test No. 3 is made every six months. The purpose of the inspection is to establish the conformity of the electrical characteristics of the equipment with the requirements of the technical specifications contained in the official documentation of the station, and also to determine the technical condition and combat readiness of the station.

Operational test No. 3 includes:

- a check for completeness of the equipment, accessories and related items of the station in accordance with official parts lists;
- a check of the mechanical state of repair of the basic, reserve and auxiliary station equipment;
- an electrical check of the equipment and individual systems of the station, including the storage batteries.

The results of the completeness check of the station (in accordance with official parts lists) are entered into the permanent documentation of the station, and missing equipment is replaced immediately.

Mechanical defects noted during the check are immediately eliminated. Subject to an electrical check are the basic parameters of the station:

1. Power at transmitter output.
2. Receiver sensitivity
3. Transmission line efficiency

4. Antenna traveling-wave ratio

5. Attenuation introduced by left and right branches of frequency filter section with signal traveling in the forward (from transmitter to antenna) direction.

6. Residual attenuation in telephone channels

7. Crosstalk in telephone channels

8. Telegraph distortions

9. Consumption of electric power from storage batteries and a-c mains

10. Storage battery capacity

11. Insulation resistance of power conductors in connecting cables.

The operational test of the station includes a check of antenna plugs, line boards, input recesses (van ports) and repair cables.

The results of operational test No. 3 are entered in the official permanent documentation of the station and in the operational log. Defects noted are immediately eliminated.

According to the results of the inspection an overall evaluation is made of the technical status and combat readiness of the station.

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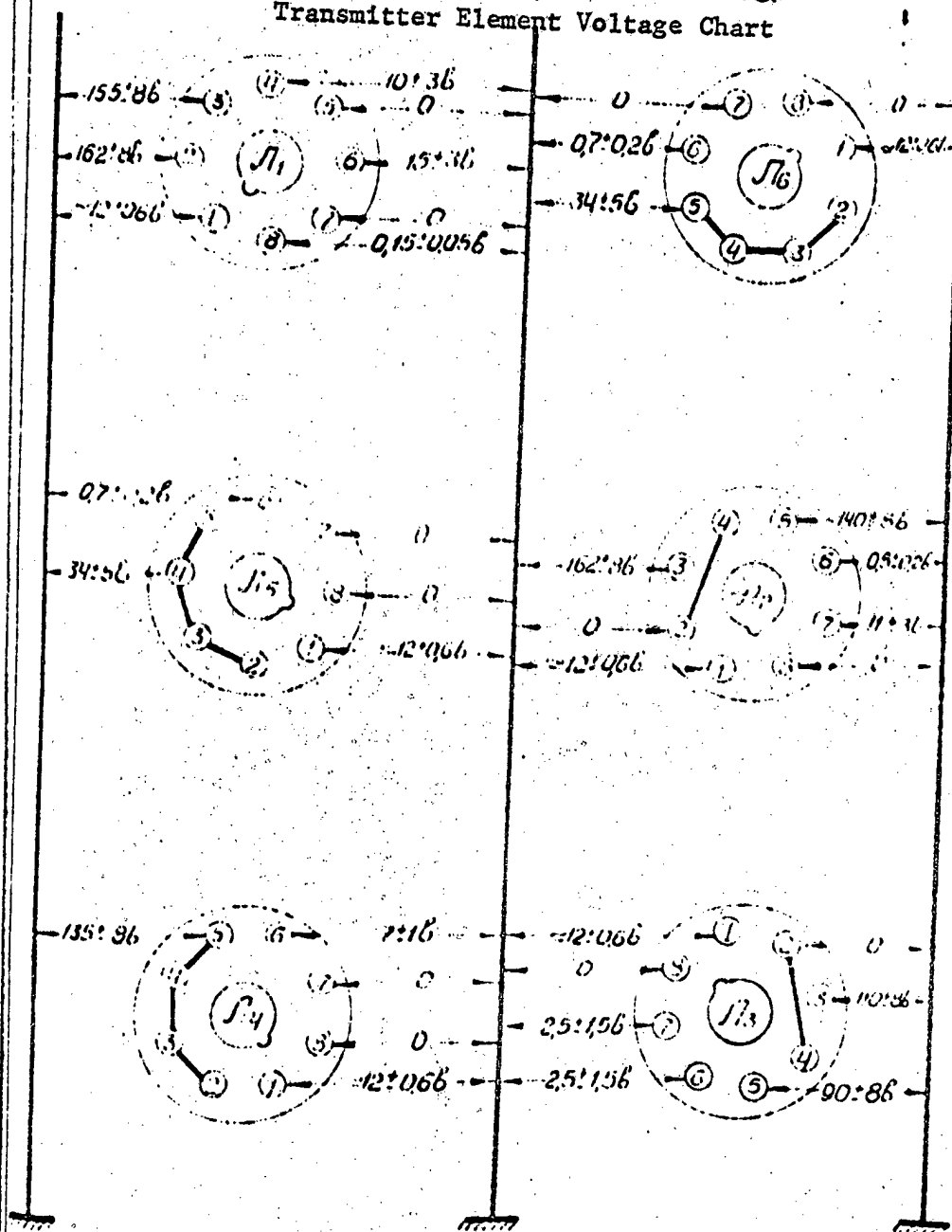
APPENDIX 3

Полон 359 Версия 1.0

Карта напряжений элементов передатчика

Transmitter Element Voltage Chart

Приложение 3



Note: Check voltages with KVM-1 tester

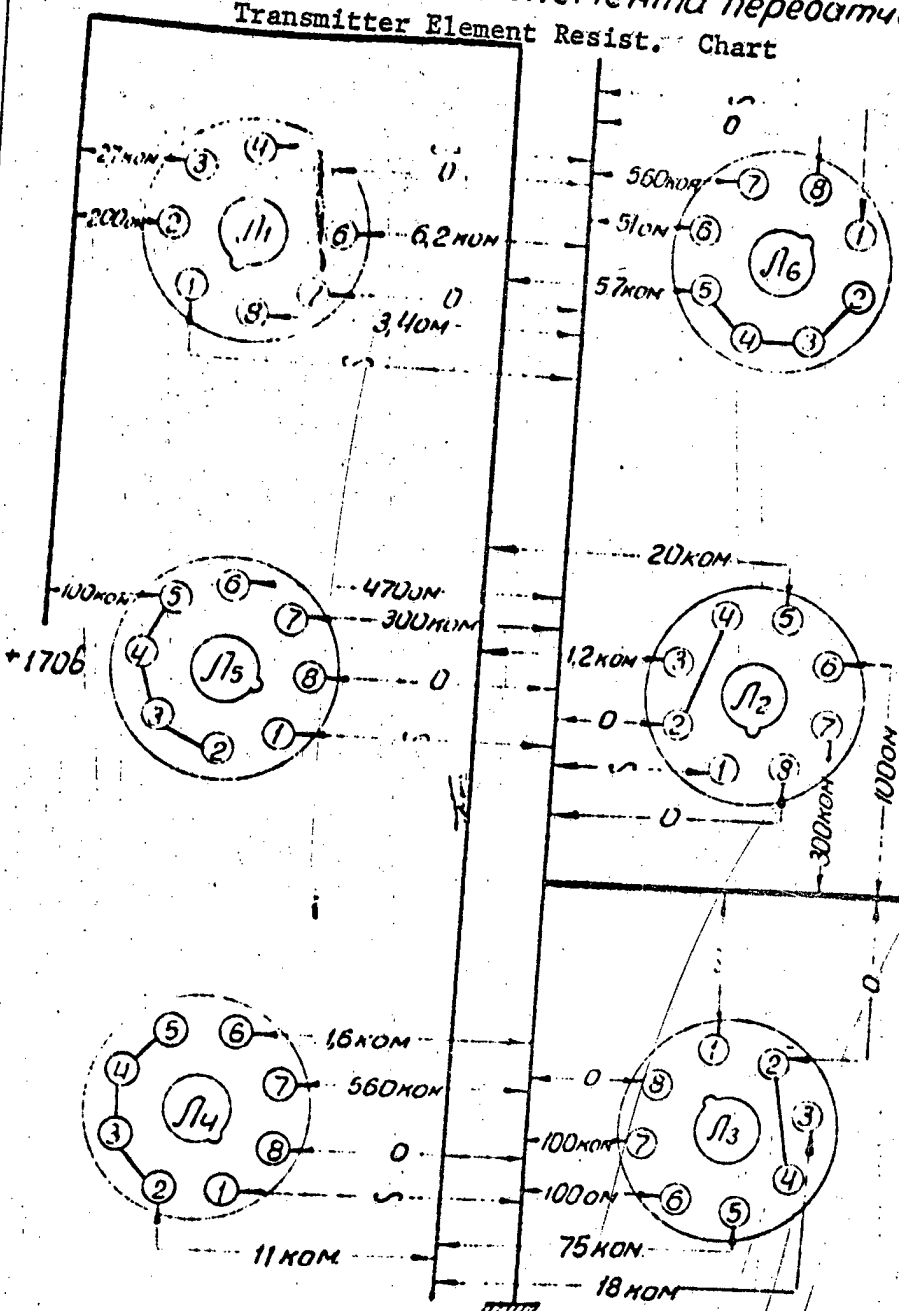
Примечание: Напряжения измерить прибором КВМ-1.

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Карта сопротивлений элемента передатчика.
Transmitter Element Resist. Chart

Лист 360 Листов 370



Примечание. Сопротивления измерять при вынутых лампах прибором ТТ-2 или Ц-20.

Note: Check resistances, with tubes removed, with a TT-2 or TS-20 tester.

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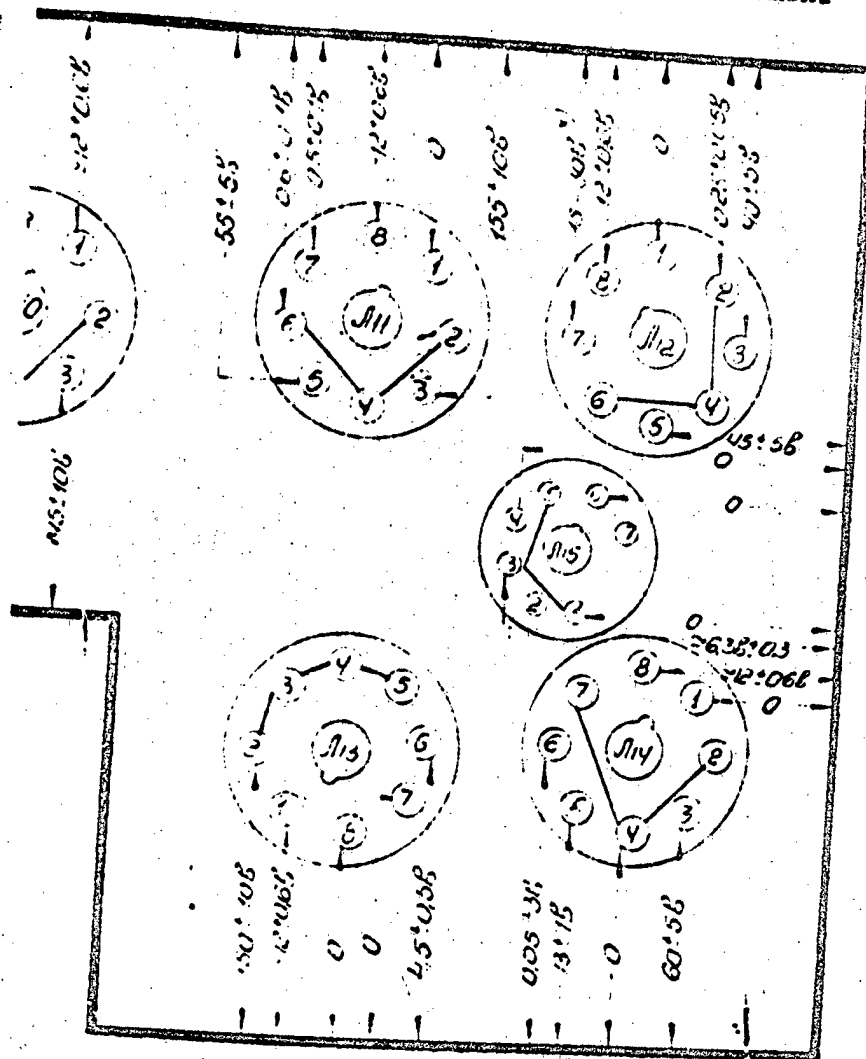
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Лента УНЧ приёмника

Resistance Chart for Receiver IF Amplifier Element



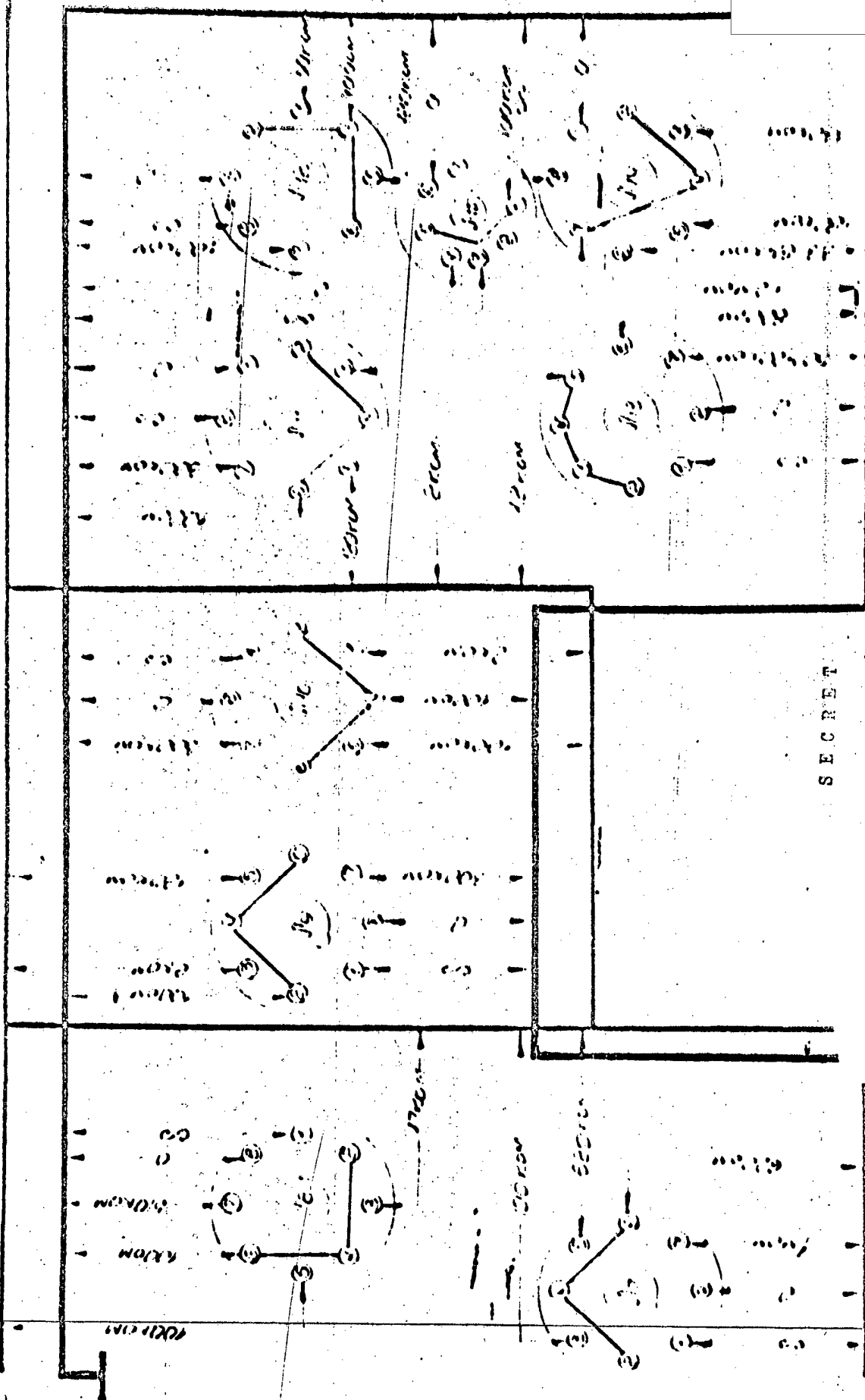
Лента УНЧ приёмника
МКУ 361. Прот. 3.10

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E.
 G.
 H.
 I.
 J.
 K.

Коротко о требованиях к участникам

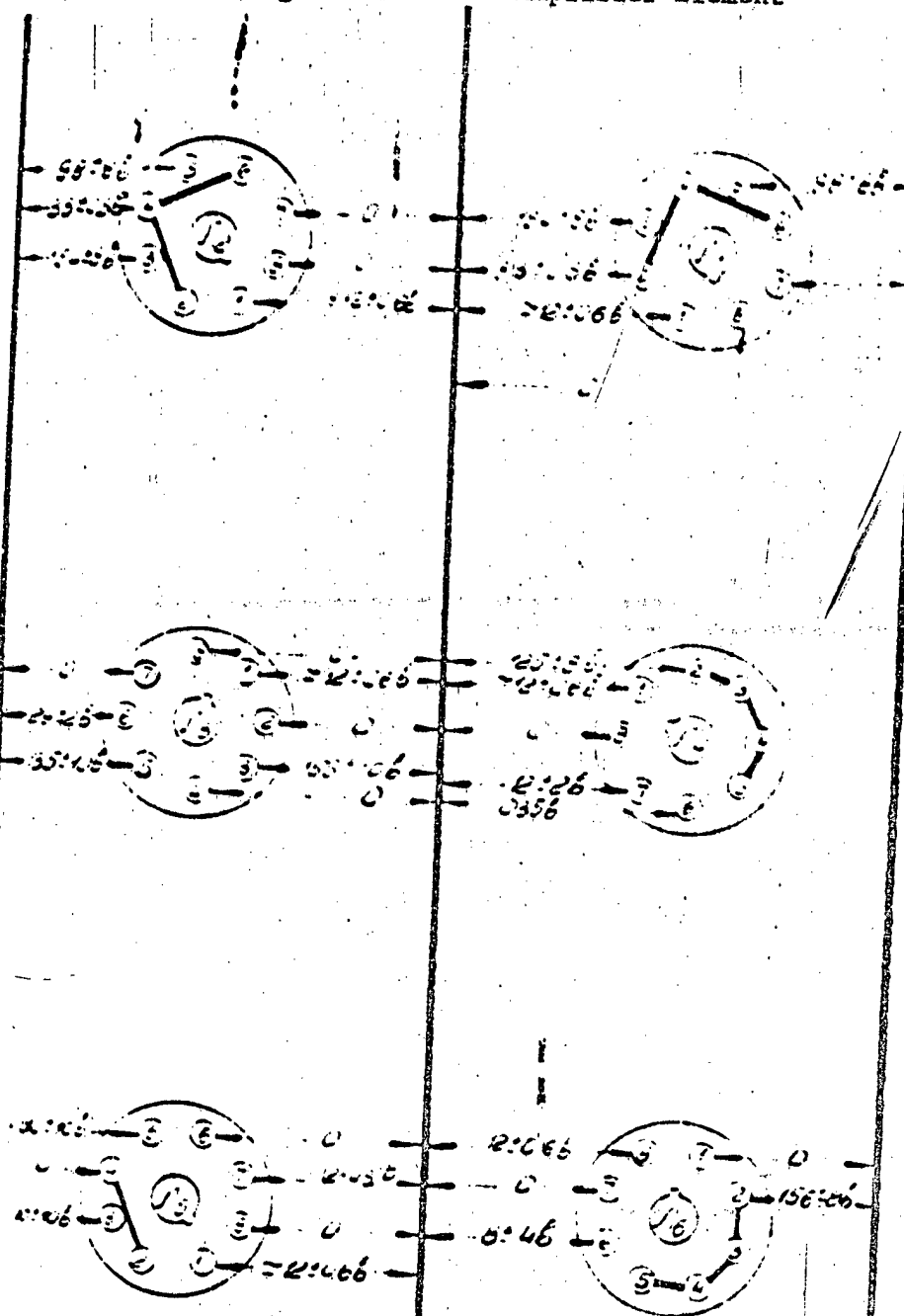
Resistance Chart of Receiver IF Amplifier Element:



E.
 E.
 E.
 E.
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 E.

Карта напряжений элементов УЗЧ

Voltage Chart of HF Amplifier Element



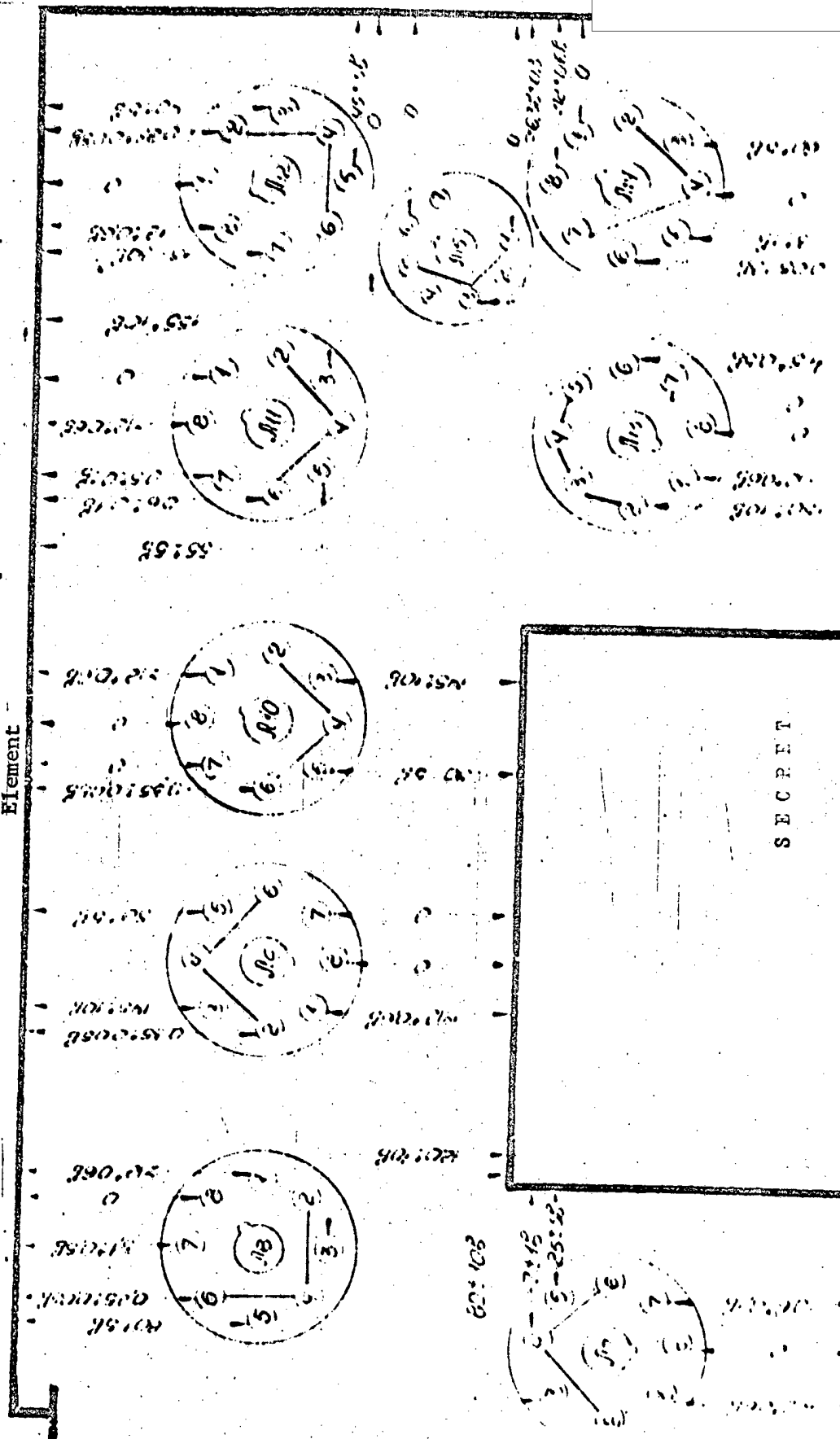
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Note: Check voltages with a KVM-1 Tester
 замечание: Напряжения измерять прибором КВМ-1

SECRET

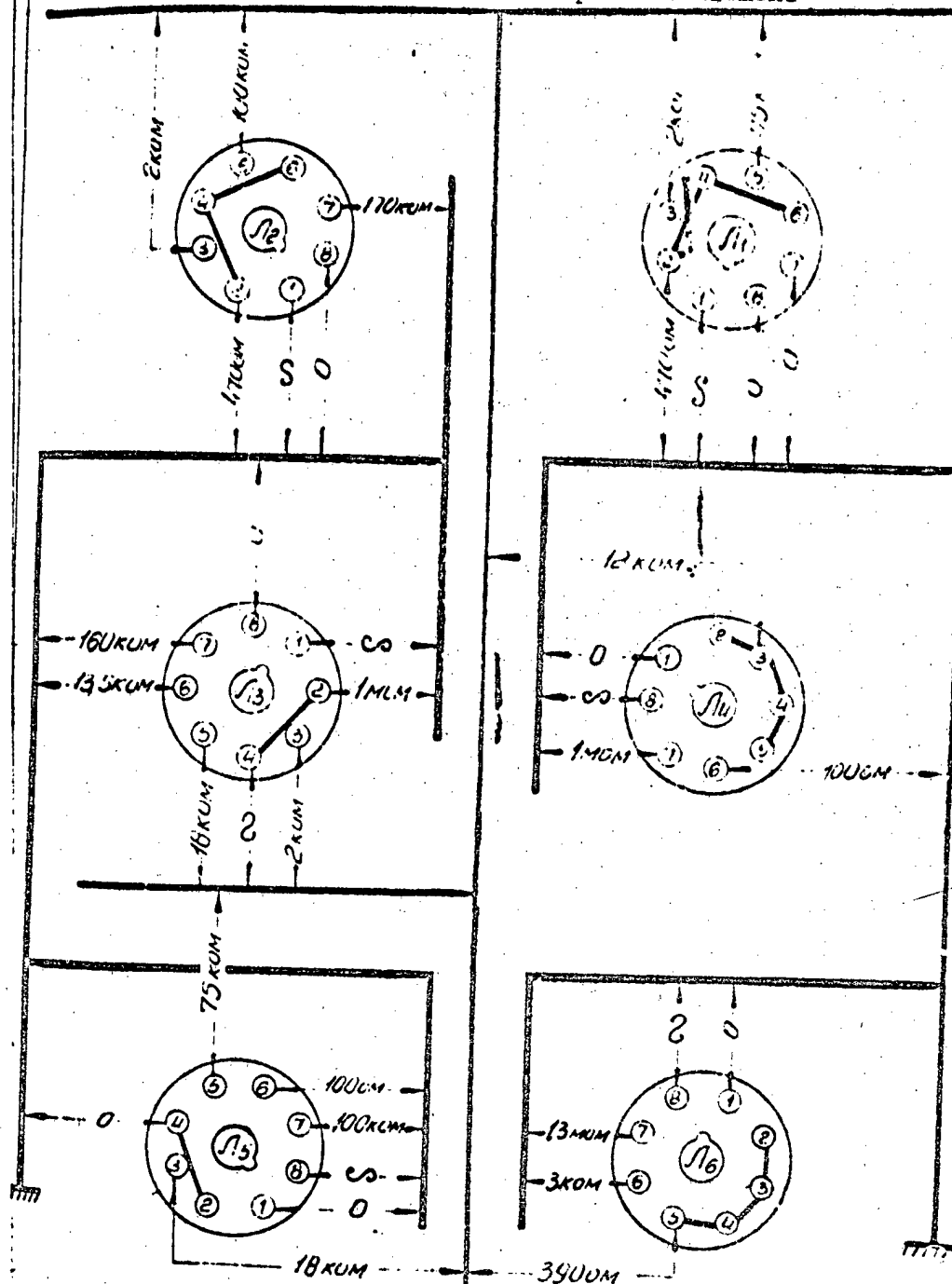
Карта
напряжений элементов ИЧ приемника

Voltage Chart for Receiver IF Amplifier
Element



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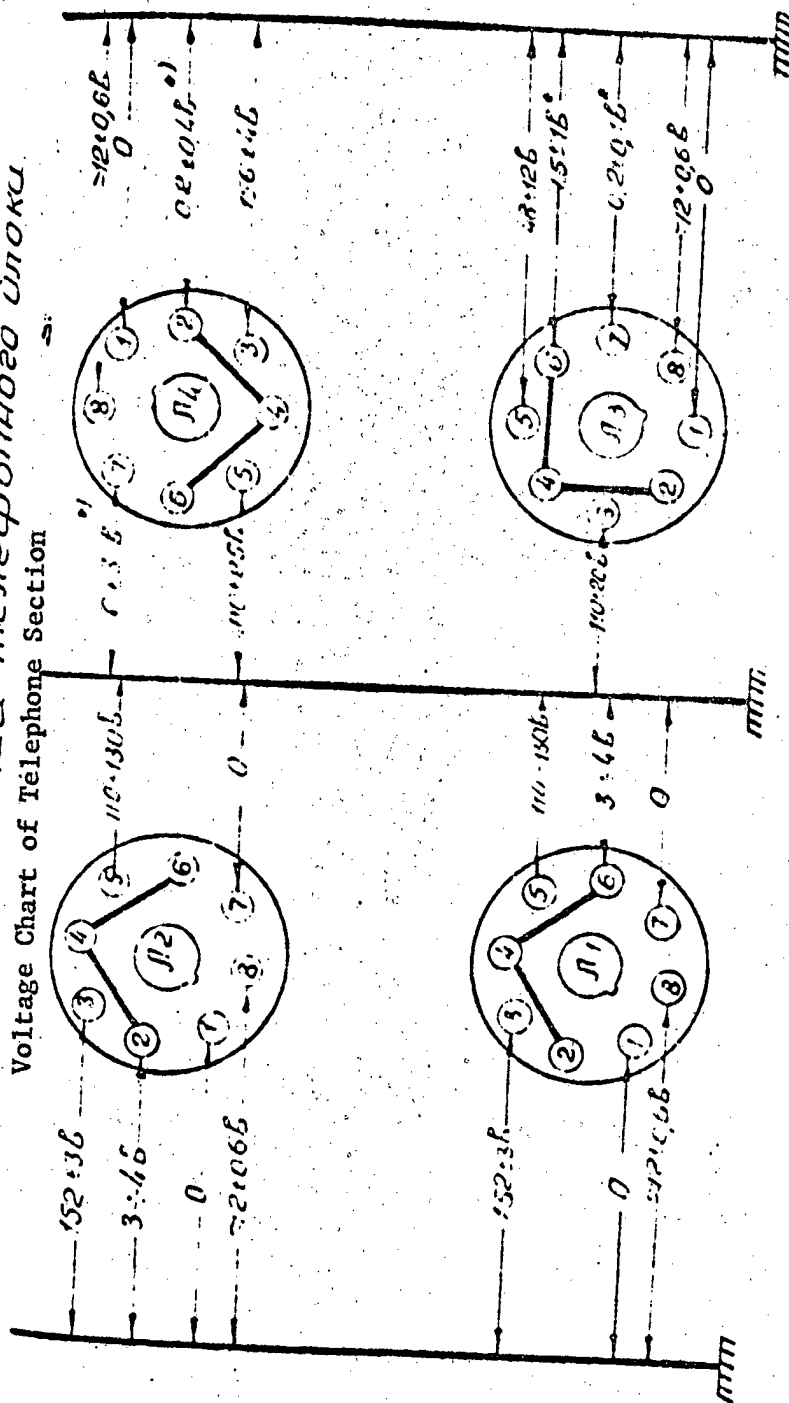
Карта сопротивлений элемента УВЧ Resistance Chart of HF Amplifier Element



Примечание: Сопротивления измерять при
вынутых лампах прибором ТТ-2
или Ч-20. NOTE: Check resistances, with
tubes removed, with a TT-2
or Ts-20 Tester.

5
 6
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Voltage Chart of Telephone Section



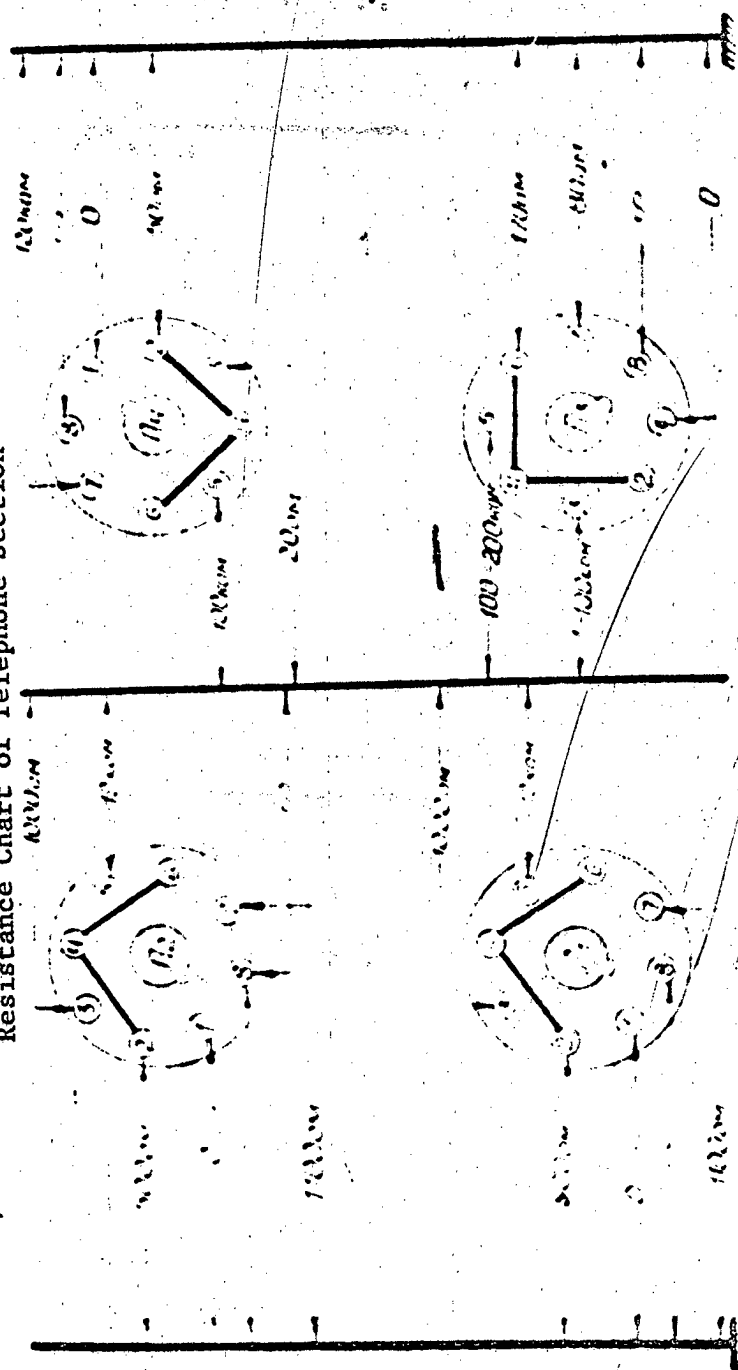
Применение: Напряжения
или 1:20, отмеченные
измерять прибором ТТ-2
или прибором КВМ-1

NOTE: Check voltages indicated by the KVM-1 tester with a TT-2 or Ts-20 device.

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JENSEN

Карта сопротивлений телефонного аппарата Resistance Chart of Telephone Section



Примечание: Сопротивления измерять при вынутых лампах прибором ТТ-2 или Ц-20

Note: Check resistances, with tubes removed, with a TT-2 or Ts-20 tester.

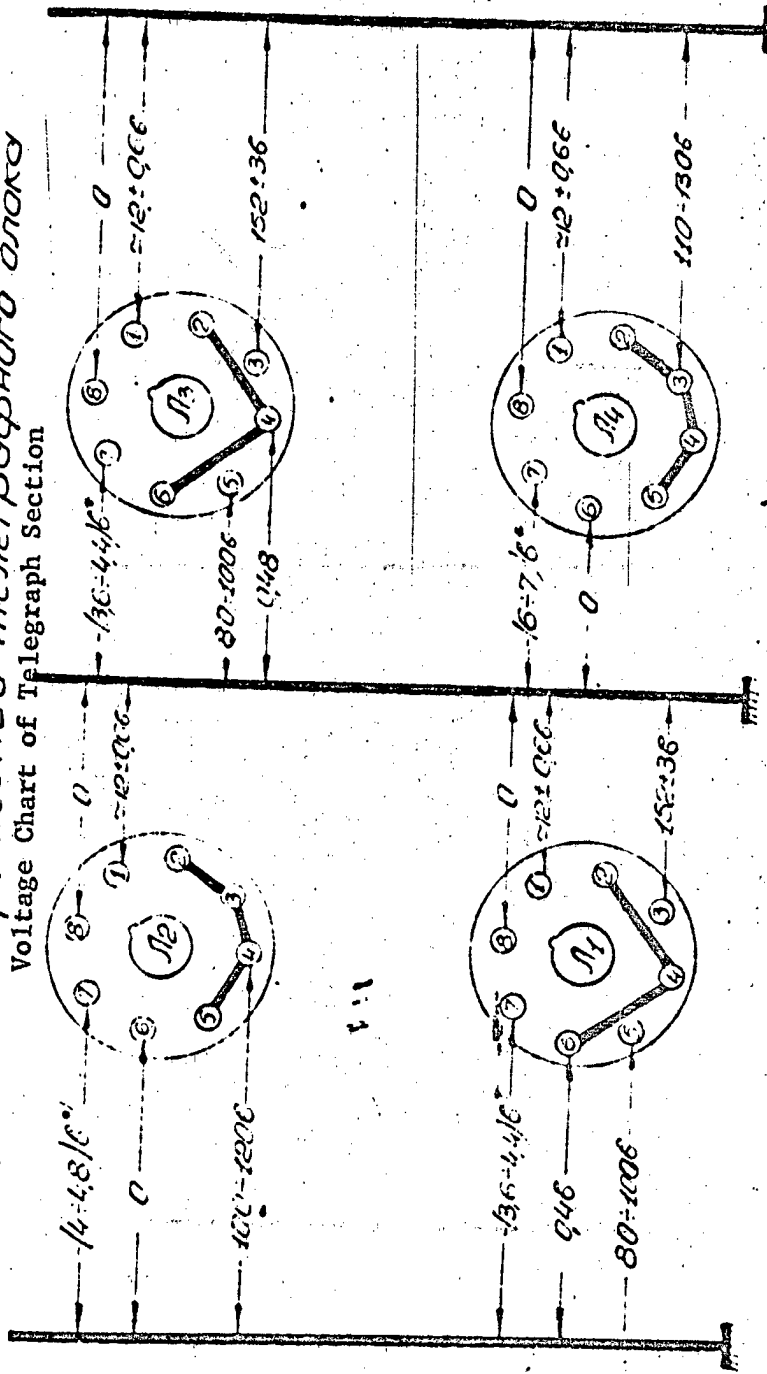
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Техническое описание

Лист 367

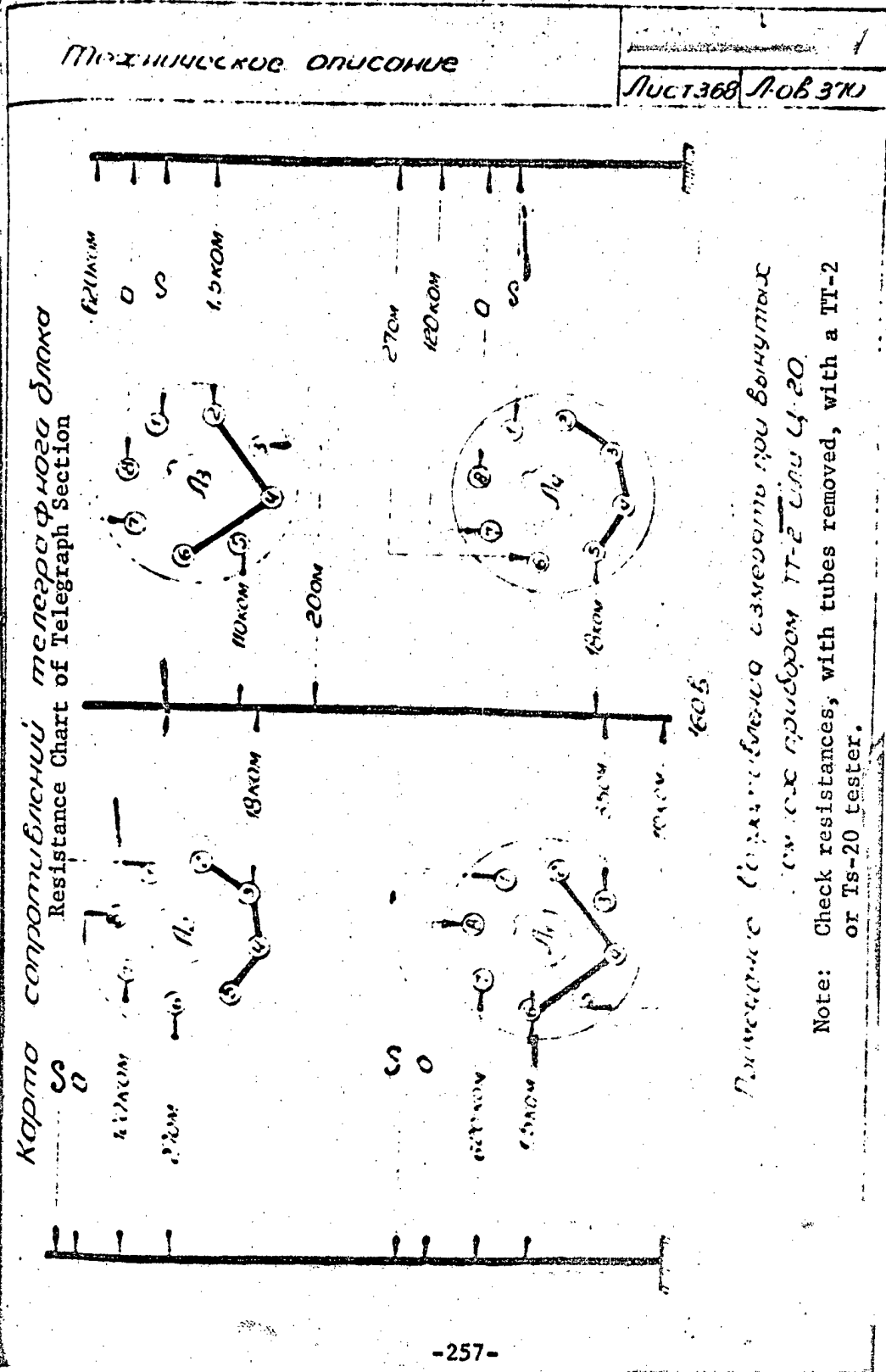
Л-06 370

Карта напряжений телеграфного блока
Voltage Chart of Telegraph Section



Примечание. Напряжения измерять прибором ТТ-2 или Ц-20
отмеченные 4-прибором КВМ-1.
Note: Check voltages, determined by KVM-1 tester, with a TT-2 or
Ts-20 device.

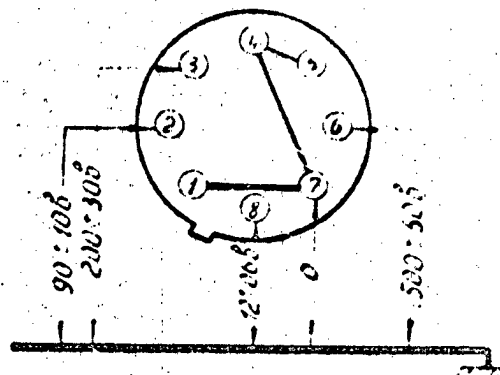
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Карта напряжений усилителя мощности в рабочем режиме

Chart of Power Amplifier Voltages in Operating Mode

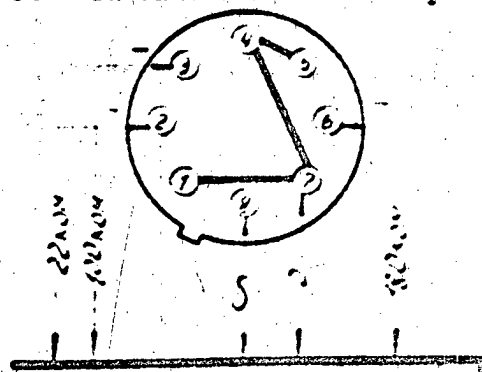


Примечание: Напряжения измерять ламповым
вольтметром с высокочастотным дросселем

Note: Check voltages with a tube voltmeter with HF choke.

Карта сопротивлений усилителя мощности

Chart of Resistances of Power Amplifier



Примечание: 1) У контактов обозначен знак
полюсов омметра
of ohmmeter in-
dicated at con-
tacts. 2) Measure
resistances with tube
removed with a TT-2 or Ts-20 tester

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APPENDIX 4

POWER SUPPLY CONVERTER DATA TABLE

Designation of Element	Contacts of Block +	Voltage, V	Current		Pulsation of Rectified Voltage (Eff. Value %)
			(Load or Consumption)		
Transmitter power converter	+12v-Comm.	+12**	Not more than 1.65a		Not more than 0.07
	127, -127g	127***	Not more than 0.26a		Not more than 0.04
	+170-Comm.	+172 ±3	72 ± ma		
Receiver power converter	-25-Comm.	-25 ±1	1.2 ma +0.2		
	12, -12g	~12.6 ±0.5	0.75a		
	+12v-Comm.	+12**	Not more than 1.55a		Not more than 0.07 ^s
Line circuit power converter	127 ₁ -127 ₂	~127***	Not more than 0.35a		Not more than 0.02
	+160-Comm.	+162 ±3	68 ±3 ma		
	+60 -60	65 ±2	0.6 ma		
Power amplification section power converter	12 ₁ -12 ₂	~12.6 ±0.5	1.5a		
	+12v-Comm.	+12**	Not more than 0.5a		Not more than 1.5
	127 ₁ -127 ₂	~127***	Not more than 0.1a		Not more than 1.5
	+60-Midp.	+62 ±2	0.3a		
	-60-Midp.	-62 ±2			
	12 ₁ -12 ₂	~12.6 ±0.5			
		+12**	Not more than 7.5a		Not more than 2
		~127***	Not more than 0.78a		Not more than 2
		+500 ±30	100 ±2 ma		
		+200 ±10	10 ±1 ma		
		-80	3.5 ±0.5 ma		
		~12	0.9a		

* The first contact corresponds to the polarity indicated in the voltage chart.
** Only with battery power.
*** Only with a-c mains power.

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